Contract No. NAS 9-18142
Line No. 2
DRD No. SE-1299T

MANUFACTURE AND EVALUATION OF LI/BCX DD CELLS

FINAL REPORT
CONTRACT NO. NAS 9-18142

S. Meyer, E. Takeuchi

Submitted to

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center

June 1990

Wilson Greatbatch Limited
10,000 Wehrle Drive
Clarence, NY 14031

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DISTRIBUTION LIST

Contract No. NAS 9-18142

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ABSTRACT

This contract is divided into four main tasks: cell manufacture, acceptance and lot certification of cells, performance testing of cells, and abuse testing of cells. Li/BCX 149 DD cells (PN 3B2085-XA) were built according to the provisions of Electrochem Industries Quality Plan 17096. Acceptance and lot certification testing was performed according to NASA JSC Document EP5-83-025, Revision B. Acceptance testing included open circuit and load voltage check, visual examination, size and weight measurements, and high temperature exposure. Lot certification tests were performed for capacity performance and for performance under conditions of thermal and electrical abuse. These tests included 149°C exposure, capacity discharge, fuse check, high temperature exposure, high rate discharge, short circuit, vibration, and overdischarge testing. A quantity of 200 cells was delivered to Johnson Space Center for life test evaluation. A parametric evaluation of the capacity discharge of Li/BCX DD cells was performed over a variety of temperatures and discharge rates. This testing served to map the performance capability of the cell. Tests were also performed over a variety of electrical and thermal abuse conditions. Abuse tests included short circuit, charging, overdischarge, high temperature exposure, shock, and vibration.

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1. Introduction

The Lithium/BCX DD cell produced by the Electrochem Industries Division of Wilson Greatbatch Limited was redesigned to withstand exposure to elevated temperatures. This request was made by NASA in response to new space application lot sample screening techniques involving thermal soaks at 149°C. Contract NAS 9-17821 addressed the specific cell design improvements for the DD cell. The present contract is for the qualification of the newly designed Li/BCX 149 DD cell.

This contract is divided into the following basic tasks: manufacture of Li/BCX 149 DD cells, acceptance and lot certification testing, electrical performance testing, and abuse testing.

In Task 1, the DD cells were constructed according to the design proved to withstand the 149°C exposure under contract NAS 9-17821. This design uses a shortened cell stack and a thicker header compared to the standard design employed by Electrochem Industries in their commercial product. The cells were made by the standard Electrochem Industries manufacturing practices as modified by NASA JSC Document EP5-83-025, Revision B.

Task 2 was directed at the lot acceptance and certification testing of the cells as outlined in the NASA JSC Document EP5-83-025, Revision B. This testing was conducted on a lot of sufficient size to provide enough cells for the testing outlined below and for delivery of 200 cells to JSC for life test evaluation.

Task 3 was carried out to map the performance capability of the cell. Electrical performance testing of fresh cells was conducted over four discharge temperatures and four different loads. Cell currents, voltages, and temperatures were monitored during discharge, and capacities were determined for a variety of voltage cutoffs.

Task 4 involved cell testing over a variety of electrical and thermal abuse conditions. The response of the cells to short circuits, charging, overdischarging, high temperature exposure, and shock and vibration was examined.

This work was funded under Contract NAS 9-18142 administered by the Johnson Space Flight Center under the direction of Mr. B. J. Bragg.

2. Manufacture Li/BCX 149 DD Cells (Task 1)

A total of 672 Li/BCX 149 DD cells (four lots) were constructed according to the provisions of Electrochem Industries Quality Plan 17096. Table 1 indicates the date code, certification lot number, and pour date for each tray of 48 cells. A quantity of 200 cells was delivered to JSC following the completion of acceptance and lot certification tests. The remaining cells were utilized for performance and abuse tests.

TABLE 1: Date/Lot Code Parameters

Date Code	Certification Lot #	Pour Date	No. of Cells
A249A	1	15-Jun-89	48
A249B	1	15-Jun-89	48
B249A	2	16-Jun-89	48
B249B	2	16-Jun-89	48
B249C	2	16-Jun-89	48
C249B	3	20-Jun-89	48
C249C	3	20-Jun-89	48
D249A	3	20-Jun-89	48
D249B	3	20-Jun-89	48
D249C	3	21-Jun-89	48
E249A	3	21-Jun-89	48
E249B	3	21-Jun-89	48
A299A	4	20-Jul-89	48
A299B	4	20-Jul-89	48
		Total	672

The following general documents for the commercial DD cells were modified as required and used in cell production:

1. Bill of Materials
2. Product Drawings
3. Bulk Specifications
4. Receiving Inspection Instructions
5. Build Instructions

6. Quality Control Instructions

7. Lot Travelers

Raw materials, piece parts, subassemblies and final assemblies are defined by drawings. These drawings include appropriate dimensional, physical, chemical, marking, and processing requirements. In addition, work instructions for fabrication and inspection operations are written and referenced on the drawings and/or travelers.

All inspections (receiving, in-process, and final) are described in quality control instructions and all fabrication/inspection operations and operators are identified on work travelers.

All drawings are listed on a Bill of Materials (B/M), indented to distinguish between assemblies, sub-assemblies, component parts and raw material.

WGL has developed a carefully controlled system of implementation and modification of manufacturing and control processes. This set of procedures was followed in the manufacturing of all cells required for this contract. The steps which were taken to insure proper processes and documentation are the following:

1) Following an approved design concept, preliminary drawings are developed which are listed in an indented format to reflect a distinction between assemblies, subassemblies, piece parts, and raw materials. These drawings must be signed by Engineering, Quality, Manufacturing, Technology, and Purchasing representatives prior to release to the manufacturing floor.

2) Raw materials are documented in a drawing format and include appropriate physical and chemical parameters and tolerances.

3) Detailed drawings are prepared for the cells assembled in the pack configuration form.

4) Additional Build Instructions are developed to augment drawing specification where appropriate.

5) Travelers are generated which specify the sequence of operations and provide for component traceability, operator/inspector identification, and the quantity accepted/rejected and why.

6) Discrepant material is quarantined pending disposition by a Material Review Board (MRB), consisting of Engineering, Quality, Manufacturing, and Technology representatives. When appropriate, Purchasing, Marketing, and Customer representatives may participate.

3. Acceptance and Lot Certification Testing (Task 2)

Acceptance testing was carried out according to reference document NASA JSC Document EP5-83-025, Revision B. The acceptance test requirements outlined therein involve the measurement of the open circuit voltage, visual inspection, physical measurement of the cell size and weight, and 71°C exposure of all cells manufactured. A total of 657 cells successfully passed the acceptance test requirements. Acceptance test data were packaged with the cells and shipped to JSC.

Lot sample tests for cell capacity, and thermal and electrical abuse were also carried out according to the aforementioned reference document. The number of cells required for each test was based on a percentage of the production lot size. For a lot size of 657 cells, this entailed a total of 129 cells broken down as follows: four cells were subjected to the 149°C exposure test; 41 cells were discharged to determine capacity and were then subjected to forced overdischarge conditions as described in NASA JSC Document EP5-83-025, Revision B; 41 cells were subjected to the high temperature storage/high rate discharge tests; 27 cells were subjected to short circuit conditions; 16 cells were subjected to vibration/high rate discharge tests. The tests for the certification sequence are shown in Figure 1. The complete NASA JSC Document EP5-83-025, Revision B appears in appendix A. Lot certification test results are included in appendix B.

NASA LOT CERTIFICATION SEQUENCE

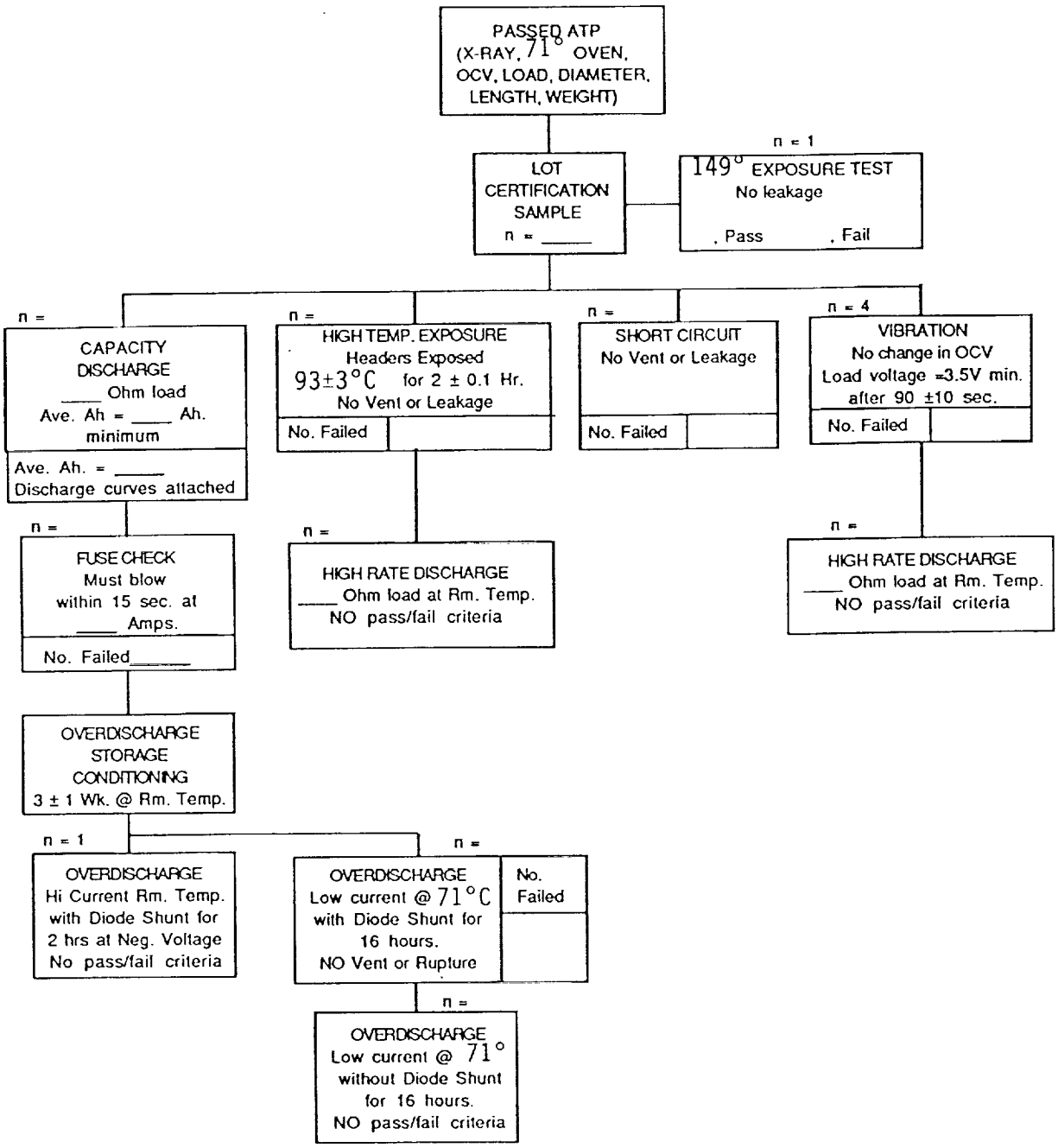


FIGURE 1. EP5-83-025 REV. B LOT CERTIFICATION SEQUENCE

4. Performance Testing (Task 3)

Electrical performance testing was conducted on 170 fresh cells according to the test matrix shown in Table 2.

TABLE 2: Electrical Performance Test Matrix

LOAD	DISCHARGE TEMPERATURE			
Ohms	**-40°C**	**-18°C**	**RT****	**71°C**
1.0	10 cells	12	12	10
1.5	10	10	12	10
5.0	10	10	12	10
10.0	10	10	12	10

** Discharge tests were conducted in a heavily insulated room during the month of July. The test temperature range for the RT group was 28°C to 32°C which is approximately 3 to 7 degrees higher than the nominal room temperature.

Following the initial discharge, a delta discharge was performed on all cells at room temperature under a 20 ohm load. Cell capacities were determined to voltage cutoffs of 3.0, 2.5, 2.0, and 1.5 volts, and delta capacities determined to 1.5 volts. Individual cell capacities are presented in Table 3 along with group averages and standard deviations. Discharge curves are presented in Figures 2 - 33. Figure 34 illustrates the relationship between average delivered capacity and rate of discharge. Results indicate that cells that were discharged under 5.0 ohms or 10.0 ohms delivered greater average capacity than cells that were discharged under 1.0 ohms or 1.5 ohms. As temperature was increased from -40°C to room temperature, the average delivered capacity of the cells increased. As temperature was increased from room temperature to 71°C, average performance was shown to decrease.

Temperature of two cells per group was monitored. Cell peak temperature values are presented in Table 4. The variation in cell temperature readings within a group may be due to variable placement of the thermocouple. A greater amount of heat is generated in the vicinity of the anode lead and consequently the position of the thermocouple on the cylindrical surface of the cell could affect the temperature reading. Graphs of the temperature versus time relationship are included in Appendix C. One cell (SN 18292) that was discharged under 5 ohms at -18°C was destructively analyzed due to inferior performance. This cell delivered only 3.6 Ah to 1.5 volts. Results of the destructive analysis are presented in the Quality Control Department Destructive Analysis Report which appears in Appendix D. There were no observed abnormalities or signs of discharge thus indicating that the cell may have experienced a short circuit which could have been induced by the test apparatus.

Table 3. Electrical Performance Test Data

TEMP (°C)	Discharge Rate (ohms)	SN	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
-40	1.0	18305	2.8	9.6	10.0	10.2	3.5
		18306	-	8.5	9.3	9.5	8.6
		18307	2.2	10.8	11.2	11.5	4.9
		18308	1.6	10.3	10.8	10.9	6.0
		18309	-	10.0	10.8	11.0	NA
		18310	-	8.8	10.7	10.8	6.1
		18311	-	7.7	8.6	8.8	6.6
		18312	1.0	6.6	7.4	7.6	7.1
		18313	2.8	8.8	9.3	9.5	3.0
		18230	2.9	8.8	9.4	9.6	0.5
		Ave.	**2.2**	**9.0**	**9.8**	**9.9**	**5.1**
		S.D.	**0.8**	**1.3**	**1.2**	**1.2**	**2.4**
-40	1.5	18263	2.1	6.3	9.2	9.4	0.1
		18264	1.6	7.4	8.0	8.2	1.2
		18265	2.0	8.3	9.2	9.4	2.2
		18266	2.0	8.3	9.1	9.4	2.1
		18267	1.6	8.1	8.7	8.9	2.1
		18268	1.9	8.0	8.7	9.0	0.1
		18269	1.4	7.3	8.2	8.5	1.9
		18270	1.2	6.6	7.4	7.7	4.3
		18271	2.8	8.5	9.0	9.2	0.1
		18272	2.7	7.5	8.2	8.3	0.1
		Ave.	**1.9**	**7.6**	**8.6**	**8.8**	**1.4**
		S.D.	**0.5**	**0.7**	**0.6**	**0.6**	**1.4**
-40	5.0	18221	2.6	13.5	14.2	14.3	1.3
		18222	2.3	11.8	12.4	12.5	5.0
		18223	2.8	13.4	14.2	14.4	8.9
		18224	2.5	13.2	14.0	14.1	3.3
		18225	2.2	11.8	12.4	12.6	11.5
		18226	2.3	13.3	13.9	14.2	10.0
		18227	2.0	11.4	12.4	12.5	7.3
		18228	2.2	11.7	12.4	12.6	2.7
		18229	3.0	11.9	12.4	12.4	0.8
		18314	2.9	10.0	12.8	13.1	4.7
		Ave.	**2.5**	**12.2**	**13.1**	**13.3**	**5.5**
		S.D.	**0.3**	**1.1**	**0.8**	**0.9**	**3.7**
-40	10.0	18347	3.1	16.8	16.9	16.9	0.7
		18348	3.2	14.2	14.4	14.5	2.6
		18349	3.8	16.2	16.4	16.5	3.0
		18350	3.1	13.7	13.9	14.0	1.4
		18351	3.2	13.6	14.0	14.1	3.6
		18352	2.3	13.3	15.3	15.6	1.7
		18353	2.7	14.3	14.6	14.6	0.9
		18354	2.4	14.7	15.0	15.1	1.6
		18355	3.5	16.0	16.3	16.4	1.9
		18356	3.3	14.0	15.4	15.6	2.8
		Ave.	**3.1**	**14.7**	**15.2**	**15.3**	**2.0**
		S.D.	**0.5**	**1.2**	**1.0**	**1.0**	**1.0**

Table 3 (continued)

TEMP (°C)	Discharge Rate (ohms)	SN	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
-18	1.0	18403	3.2	12.0	12.2	12.4	0.0
		18404	2.7	13.2	13.4	13.6	0.0
		18405	2.8	12.9	13.5	13.8	0.0
		18406	2.7	13.0	13.2	13.5	0.0
		18407	3.1	12.0	12.2	12.4	0.0
		18408	1.5	11.8	12.6	12.8	0.0
		18409	2.7	11.8	12.4	12.8	0.0
		18410	2.9	13.2	13.6	13.9	0.0
		18411	1.8	12.4	13.0	13.3	0.0
		18412	2.3	11.7	12.0	12.2	0.0
		18413	3.2	12.0	12.3	12.6	0.0
		18414	3.4	13.4	13.7	13.9	0.0
		Ave.	**2.7**	**12.5**	**12.8**	**13.1**	**0.0**
		S.D.	**0.6**	**0.6**	**0.6**	**0.6**	**0.0**
-18	1.5	18415	2.5	15.2	15.6	15.8	0.6
		18416	1.8	12.0	12.7	13.0	0.7
		18417	2.4	13.0	13.3	13.4	0.8
		18418	2.5	12.6	13.0	13.2	0.8
		18419	1.8	13.2	13.8	14.1	1.0
		18420	2.4	15.2	15.5	15.6	0.3
		18421	1.8	12.3	12.8	13.0	0.4
		18422	1.9	12.2	12.6	12.8	NA
		18423	3.1	14.1	14.3	14.4	0.4
		18424	3.1	13.6	13.8	13.9	0.3
		Ave.	**2.3**	**13.3**	**13.7**	**13.9**	**0.6**
-18	5.0	**S.D.**	**0.5**	**1.2**	**1.1**	**1.1**	**0.2**
		18285	16.5	19.4	19.5	19.7	0.1
		18286	19.6	20.8	21.1	21.3	0.4
		18287	19.7	20.9	21.0	21.2	0.2
		18288	18.0	19.9	20.1	20.3	0.1
		18289	17.9	20.1	20.4	20.6	0.2
		18290	9.6	20.8	21.3	21.5	0.4
		18291	3.0	21.0	21.2	21.4	0.6
		18292	2.8	3.4	3.5	3.6	NA
		18293	20.4	22.2	22.3	22.3	0.2
		18294	17.4	20.0	20.1	20.2	0.1
		Ave.	**14.5**	**18.9**	**19.1**	**19.2**	**0.2**
		S.D.	**6.8**	**5.5**	**5.5**	**5.5**	**0.2**
-18	10.0	18425	22.4	23.4	23.5	23.6	0.0
		18426	22.3	23.1	23.2	23.4	0.0
		18427	21.2	22.3	22.6	22.8	0.0
		18428	23.4	24.2	24.5	24.7	0.0
		18429	22.4	23.6	23.9	24.2	0.3
		18430	22.7	23.6	23.8	24.0	0.0
		18431	23.2	24.2	24.4	24.5	0.0
		18432	23.1	24.0	24.2	24.4	0.0
		18433	23.0	23.8	23.9	24.0	0.0
		18434	20.5	21.3	21.4	21.4	0.0
		Ave.	**22.4**	**23.4**	**23.5**	**23.7**	**0.0**
		S.D.	**0.9**	**0.9**	**0.9**	**1.0**	**0.1**

Table 3 (continued)

TEMP (°C)	Discharge Rate (ohms)	SN	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
29	1.0	18187	14.0	24.1	24.4	24.6	0.0
		18188	23.3	24.9	25.2	25.4	0.0
		18189	20.8	23.0	23.3	23.6	0.0
		18190	22.1	23.4	23.8	24.1	0.0
		18191	20.5	23.0	23.2	23.4	0.0
		18192	20.1	21.7	22.0	22.3	0.0
		18193	21.5	23.4	23.8	24.2	0.0
		18194	20.4	24.6	25.2	25.6	0.0
		18195	21.3	23.1	23.4	23.8	0.0
		18196	18.2	21.6	22.2	22.6	0.0
		18197	18.4	20.8	21.2	21.4	0.0
		18198	19.5	22.3	22.6	22.9	0.0
		Ave.	**20.0**	**23.0**	**23.4**	**23.7**	**0.0**
		S.D.	**2.4**	**1.2**	**1.2**	**1.2**	**0.0**
31	1.5	18231	26.9	28.0	28.2	28.3	0.0
		18232	25.8	26.9	27.0	27.1	0.0
		18233	26.4	27.4	27.5	27.6	0.0
		18234	24.4	26.3	26.4	26.6	0.0
		18235	25.8	27.0	27.2	27.4	0.0
		18236	25.7	26.8	26.9	27.0	0.0
		18237	25.3	26.3	26.4	26.5	0.0
		18238	25.4	27.2	27.3	27.4	0.0
		18239	25.4	26.4	26.6	26.7	0.0
		18240	24.1	25.2	25.4	25.5	0.0
		18241	24.4	24.8	25.1	25.4	0.0
		18242	24.4	25.2	25.4	25.6	0.0
		Ave.	**25.3**	**26.5**	**26.6**	**26.8**	**0.0**
		S.D.	**0.9**	**1.0**	**0.9**	**0.9**	**0.0**
32	5.0	18273	28.7	29.3	29.4	29.6	0.0
		18274	28.5	28.9	29.2	29.4	0.0
		18275	28.4	28.6	29.0	29.2	0.0
		18276	29.2	29.4	29.5	29.6	0.0
		18277	28.6	29.1	29.2	29.3	0.0
		18278	27.9	28.3	28.5	28.7	0.0
		18279	27.7	28.2	28.3	28.4	0.0
		18280	28.4	28.8	29.1	29.2	0.0
		18281	28.4	28.9	29.2	29.4	0.0
		18282	28.8	29.4	29.8	30.1	0.0
		18283	29.5	29.8	30.0	30.2	0.0
		18284	29.0	29.4	29.6	29.7	0.0
		Ave.	**28.6**	**29.0**	**29.2**	**29.4**	**0.0**
		S.D.	**0.5**	**0.5**	**0.5**	**0.5**	**0.0**
28	10.0	18315	28.8	29.1	29.4	29.6	0.0
		18316	28.8	29.0	29.2	29.3	0.0
		18317	28.4	28.6	28.8	29.0	0.0
		18318	28.3	28.6	28.8	29.0	0.0
		18319	28.0	28.4	28.5	28.6	0.0
		18320	27.9	28.2	28.4	28.6	0.0
		18321	29.3	29.5	29.6	29.8	0.0
		18322	28.8	29.1	29.3	29.6	0.0
		18323	28.4	28.6	28.8	29.2	0.0
		18324	27.8	28.0	28.2	28.4	0.0
		18325	29.6	29.8	29.9	30.1	0.0
		18326	29.6	29.7	29.8	29.9	0.0
		Ave.	**28.6**	**28.9**	**29.1**	**29.3**	**0.0**
		S.D.	**0.6**	**0.6**	**0.6**	**0.6**	**0.0**

Table 3 (continued)

TEMP (°C)	Discharge Rate (ohms)	SN	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
71	1.0	18211	17.5	22.4	22.8	23.2	0.1
		18212	14.8	19.0	19.2	19.5	0.0
		18213	12.3	18.9	19.4	19.6	0.0
		18214	12.5	17.4	17.8	18.1	0.0
		18215	9.7	15.7	16.2	16.6	0.0
		18216	12.8	16.0	16.3	16.6	0.0
		18217	18.0	22.0	22.3	22.7	1.1
		18218	16.4	19.1	19.4	19.8	0.0
		18219	13.2	17.3	17.6	17.8	0.0
		18220	14.0	14.9	15.2	15.5	0.0
		Ave.	**14.1**	**18.3**	**18.6**	**18.9**	**0.1**
		S.D.	**2.6**	**2.5**	**2.5**	**2.6**	**0.3**
71	1.5	18253	18.6	24.8	25.1	25.3	0.0
		18254	21.2	22.0	22.3	22.5	0.0
		18255	21.5	22.2	22.6	22.8	0.1
		18256	20.8	22.0	22.4	22.7	0.1
		18257	20.5	21.6	22.1	22.3	0.1
		18258	10.6	20.8	21.0	21.2	0.1
		18259	20.3	22.5	22.9	23.3	0.1
		18260	23.1	23.6	23.9	24.2	0.1
		18261	21.6	22.6	22.8	23.0	0.2
		18262	22.0	22.7	23.0	23.2	0.6
		Ave.	**20.0**	**22.5**	**22.8**	**23.1**	**0.1**
		S.D.	**3.5**	**1.1**	**1.1**	**1.1**	**0.2**
71	5.0	18295	26.2	26.6	26.7	26.9	0.0
		18296	25.0	25.3	25.4	25.6	0.0
		18297	25.6	25.8	26.0	26.1	0.0
		18298	25.1	25.5	25.8	26.0	0.0
		18299	23.0	23.5	23.7	23.8	0.0
		18300	25.1	25.8	25.9	26.1	0.0
		18301	24.3	25.0	25.3	25.5	0.0
		18302	24.3	24.8	25.1	25.2	0.0
		18303	26.5	26.8	26.9	27.0	0.0
		18304	26.7	27.0	27.3	27.4	0.0
		Ave.	**25.2**	**25.6**	**25.8**	**26.0**	**0.0**
		S.D.	**1.1**	**1.1**	**1.0**	**1.0**	**0.0**
71	10.0	18337	26.4	26.8	27.0	27.2	0.0
		18338	24.6	25.0	25.3	25.4	0.0
		18339	25.4	25.8	26.0	26.2	0.0
		18340	24.8	25.2	25.4	25.6	0.0
		18341	23.8	24.2	24.4	24.6	0.0
		18342	24.4	25.0	25.2	25.4	0.0
		18343	24.6	25.2	25.4	25.6	0.0
		18344	23.4	24.0	24.2	24.4	0.0
		18345	26.4	26.7	26.8	26.8	0.0
		18346	26.5	26.8	27.0	27.2	0.0
		Ave.	**25.0**	**25.5**	**25.7**	**25.8**	**0.0**
		S.D.	**1.1**	**1.0**	**1.0**	**1.0**	**0.0**

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

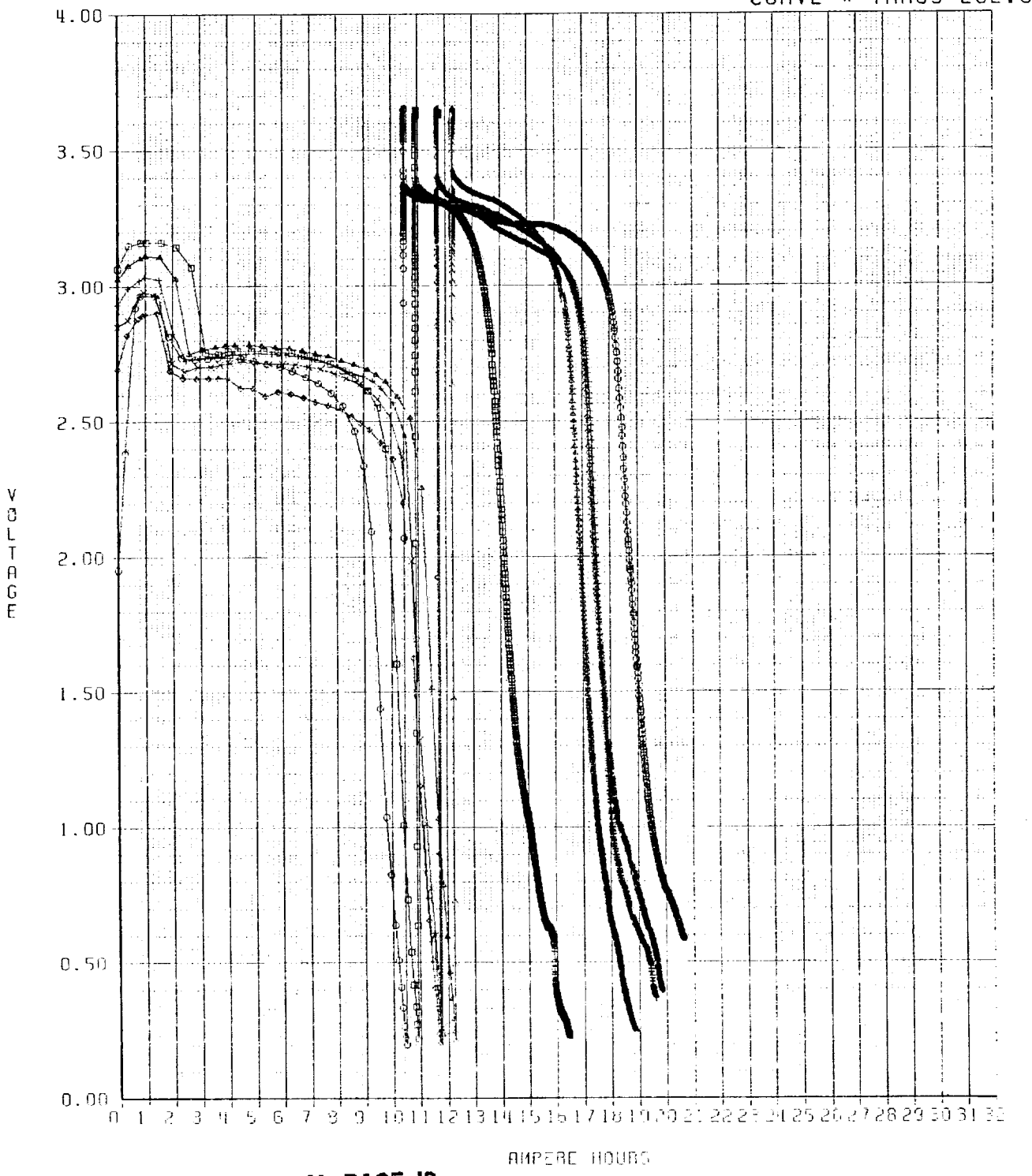
Figure 2

S/N 18305 ☐ A249B-11 S/N 18306 ◯ B249B-39
S/N 18307 △ B249C-2 S/N 18308 + C249C-44
S/N 18309 × D249A-26 S/N 18310 ◇ D249B-44
DISCHARGED AT -40°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 23AUG89
CURVE # TAR89-262.6



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GPLOT (REV. 3.1)

DAY 299 THU, OCT 26 1989 13:15:45

BCX 149DII - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 3

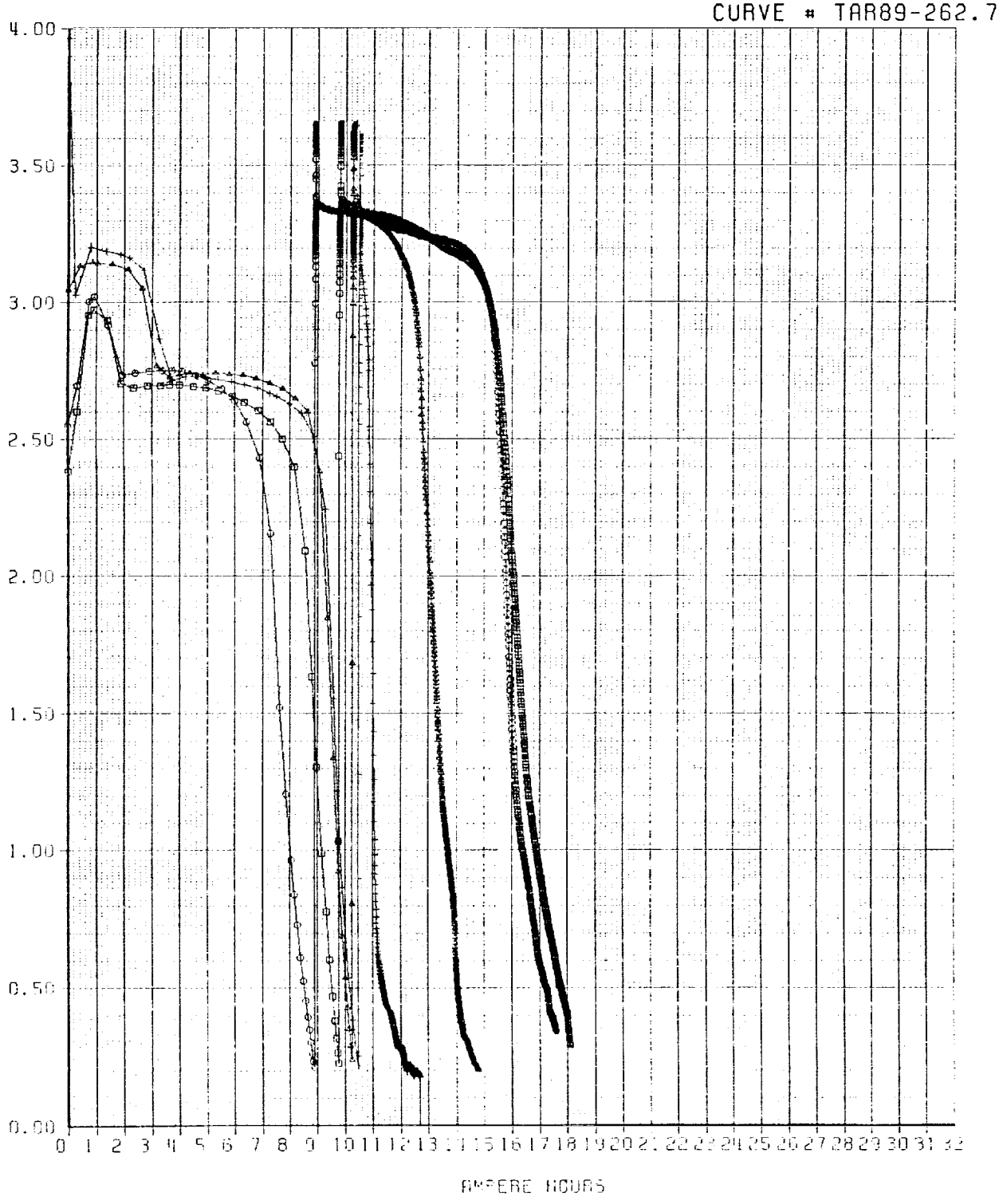
S/N 18311 ☐ D249C -5 S/N 18312 Ⓘ E249A -42
S/N 18313 △ A299A -43 S/N 18230 + A299B -29

DISCHARGED AT -40°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KAEHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 23AUG89
CURVE # TAR89-262.7



BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 4

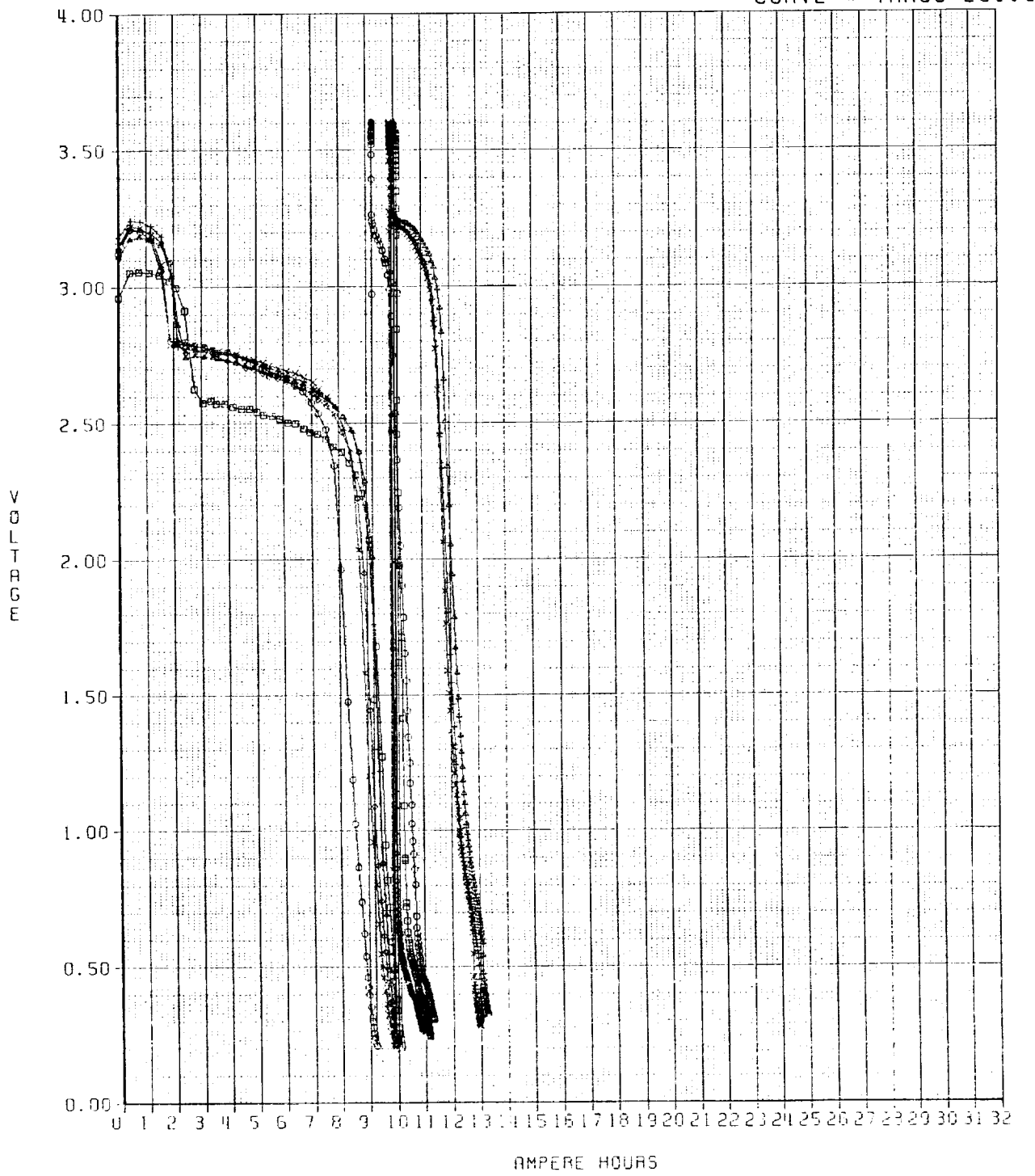
S/N 18263 □ A249B -24
S/N 18264 ⓘ B249B-8
S/N 18265 △ B249C -17
S/N 18266 + C249C-27
S/N 18267 × D249A -9
S/N 18268 ◇ D249B-45

DISCHARGED AT -40°C UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 26AUG89
CURVE # TAR89-261.6



GPLOT(REV. 3.1)

DAY 286 MON, OCT 23 1989 11:25:54 AM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 5

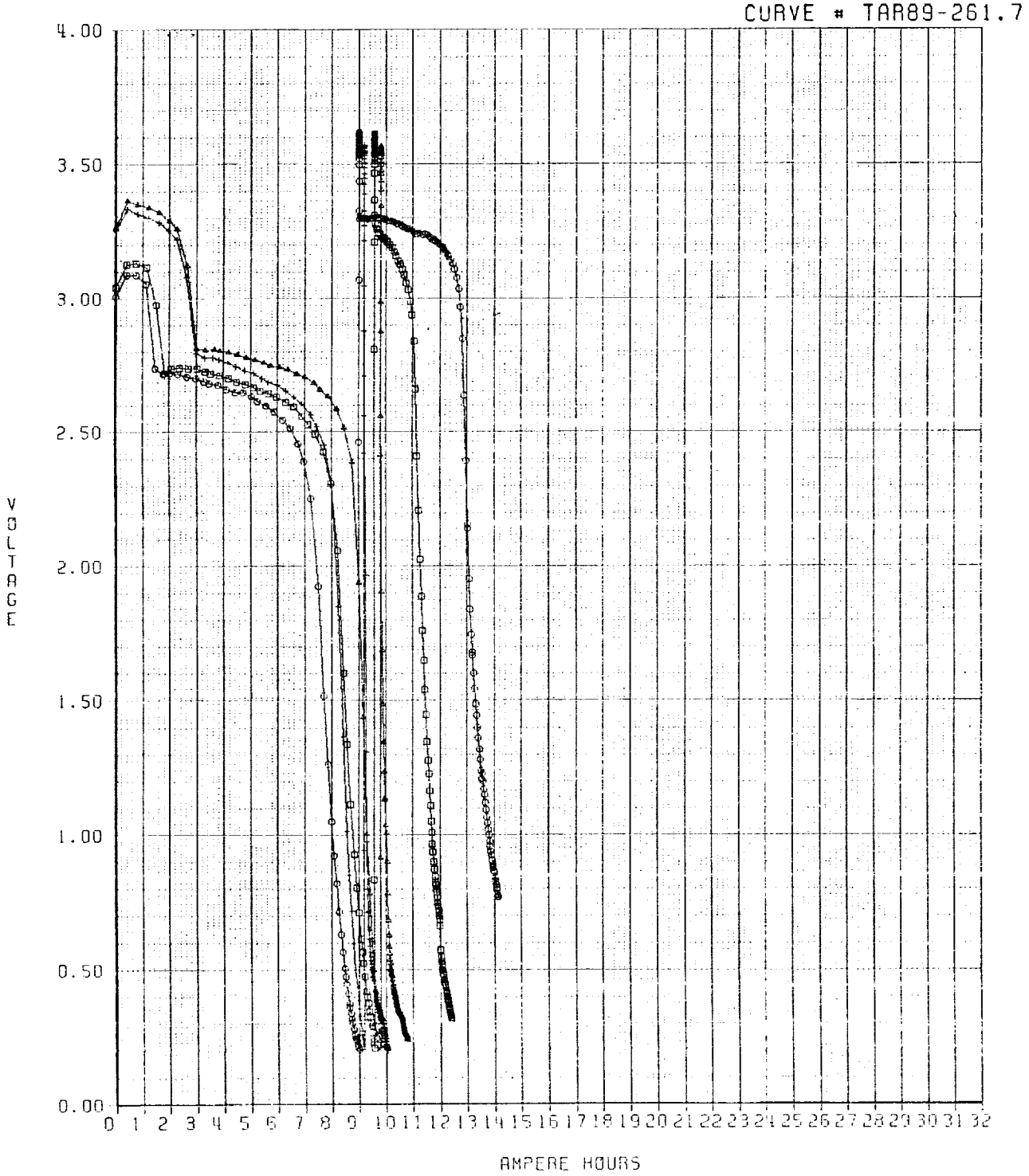
S/N 18269 ☐ D249C -9 S/N 18270 ⏱ E249A-37
S/N 18271 △ A299A -7 S/N 18272 + A299B-43

DISCHARGED AT -40°C UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 26AUG89
CURVE # TAR89-261.7



GPLOT(REV. 5.1)

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DAY 286 FRI, OCT 13 1989 3:17:32 PM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 6

S/N 18221 □ A249B -26
S/N 18222 ⏀ B249B -32
S/N 18223 △ B249C -39
S/N 18224 + C249C -26
S/N 18225 × D249A -39
S/N 18226 ◇ D249B -46

DISCHARGED AT -40°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING B. NEUMANN S. MEYER

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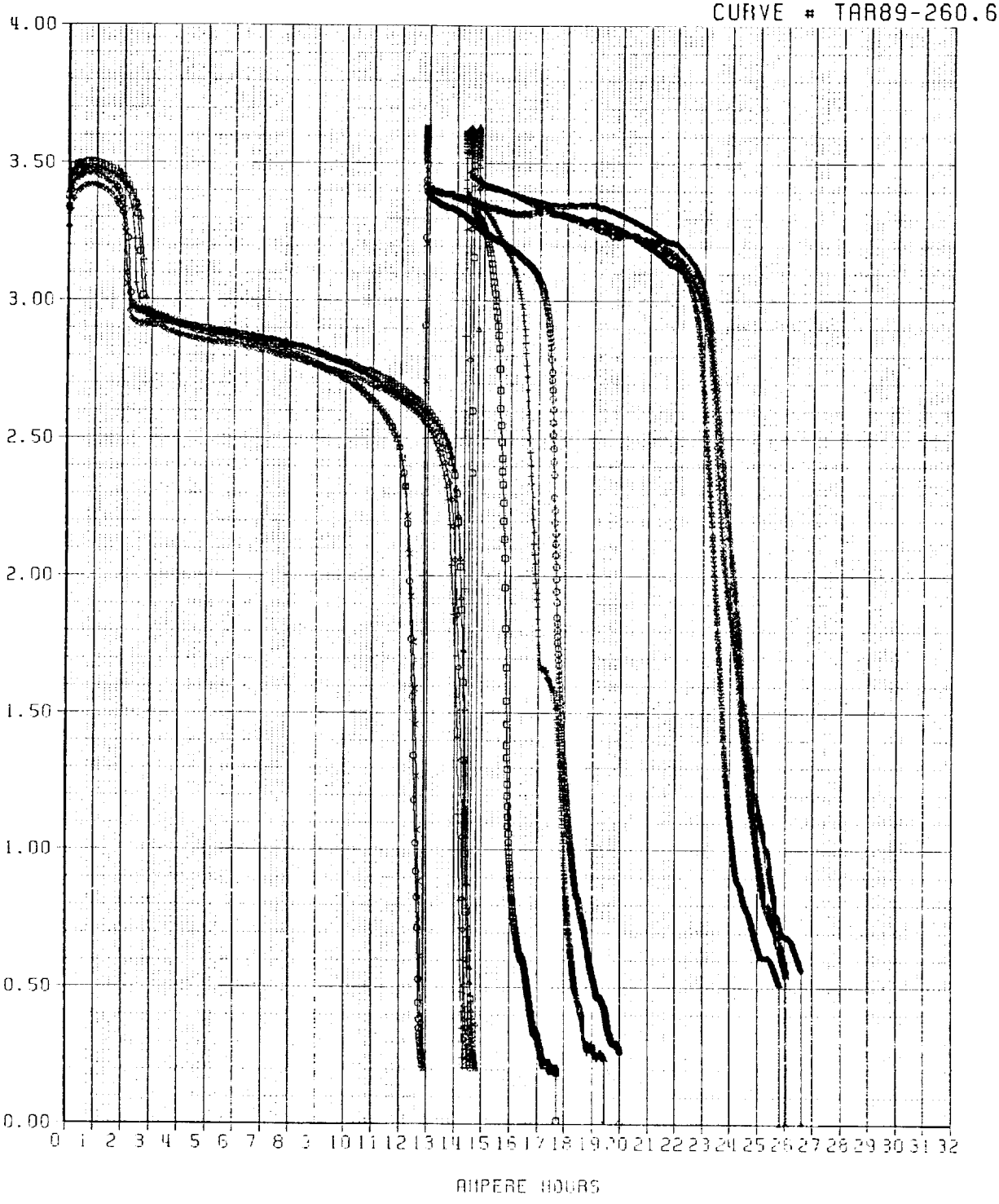
ON TEST 21AUG89
CURVE # TAR89-260.6



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BCX 1490D - 3B2085-)A
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

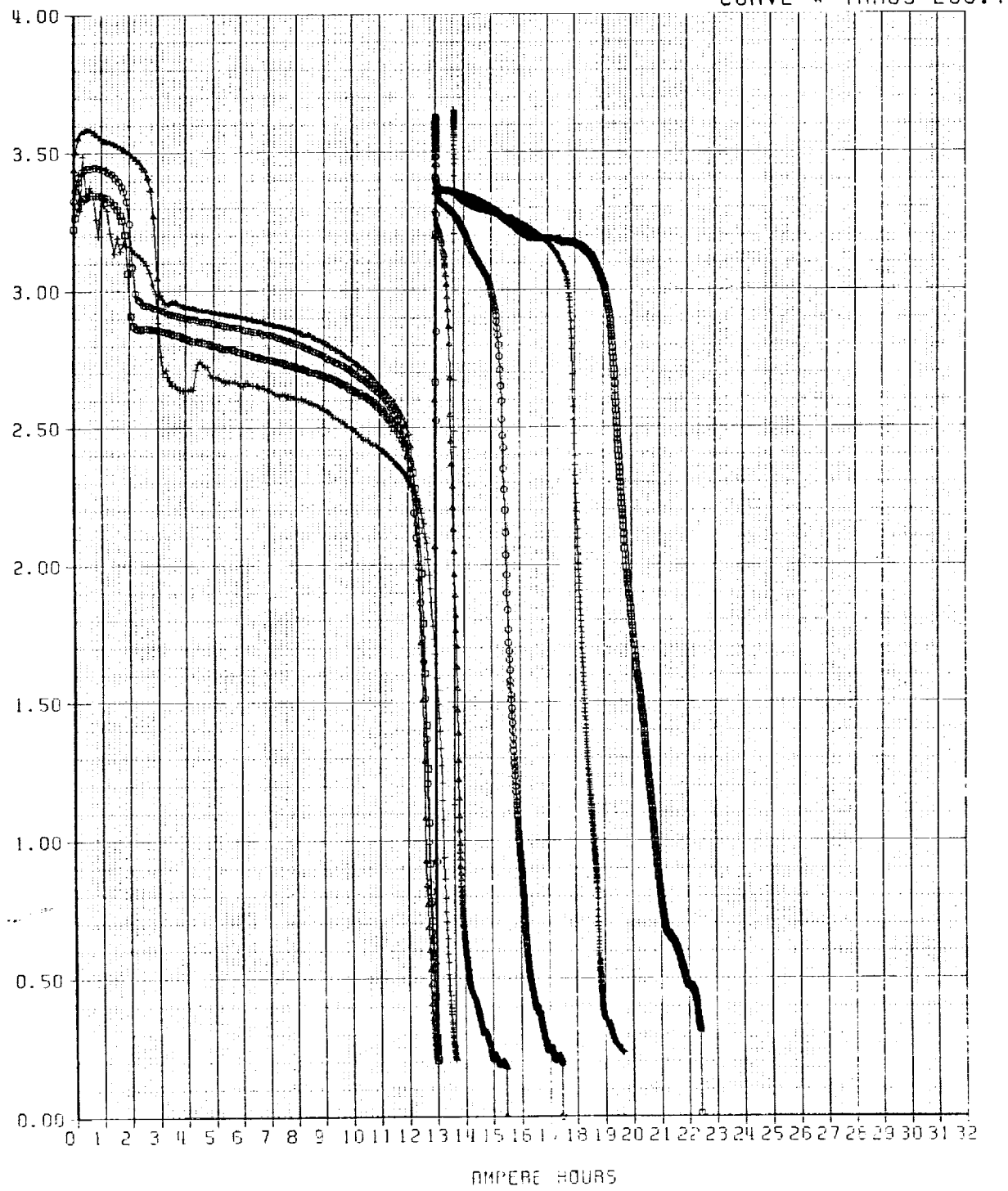
Figure 7

S/N 18227 □ D249C -22 S/N 18228 ⏀ E249A-29
S/N 18229 △ A299A -3 S/N 18314 + A299B-37

DISCHARGED AT -40°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL A. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

ON TEST 21AUG89
CURVE # TAR89-260.7



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 1:17:38 PM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 8

S/N 18347 □ A249B-16
S/N 18348 ⏀ B249B-21
S/N 18349 △ B249C-48
S/N 18350 + C249C-48
S/N 18351 × D249A-1
S/N 18352 ◇ D249B-3
DISCHARGED AT -40°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

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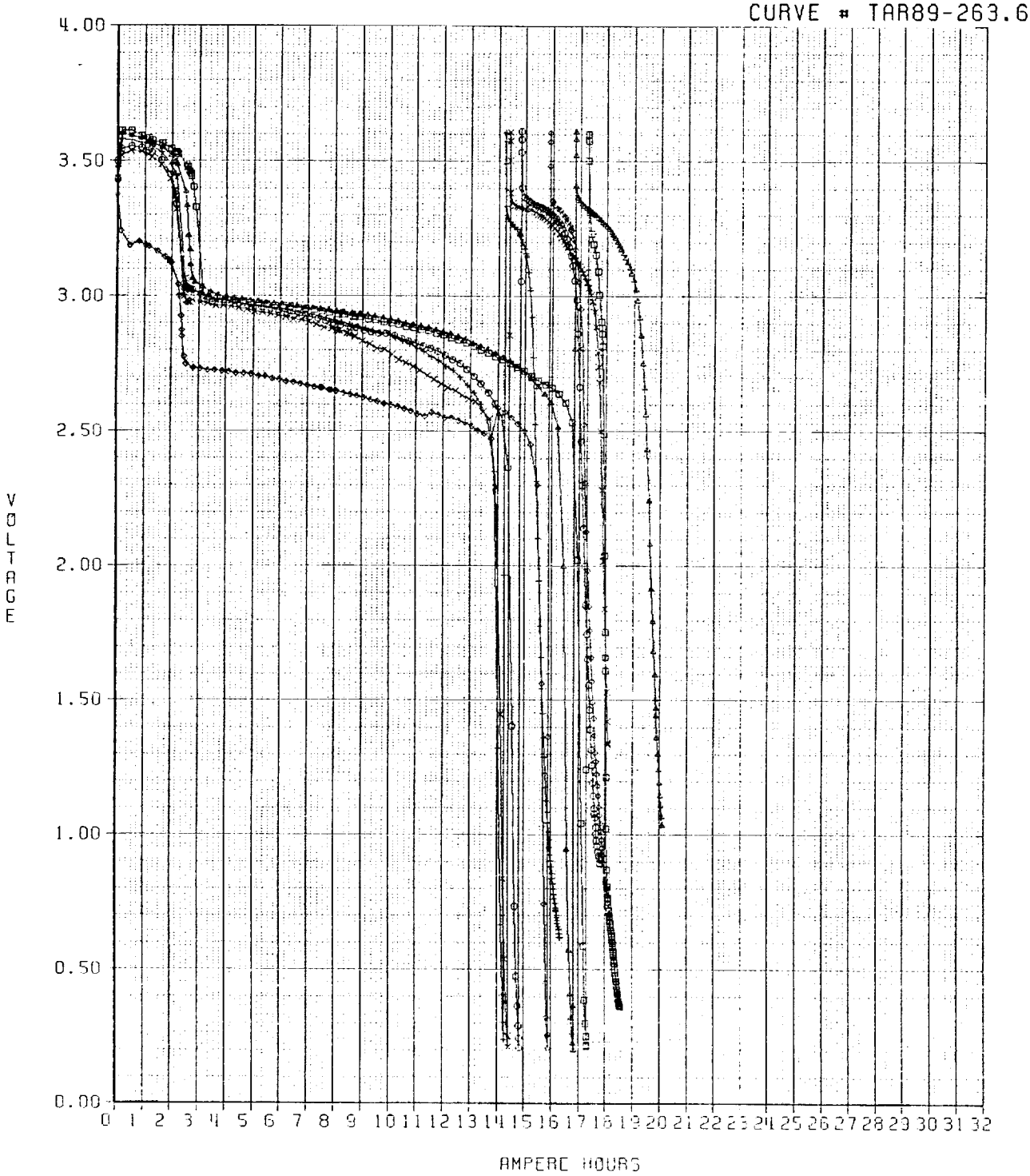
ON TEST 18AUG89
CURVE # TAR89-263.6



GPLOT(REV. 3.1)

DAT 299 THU, OCT 26 1989 3:11:00 PM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 9

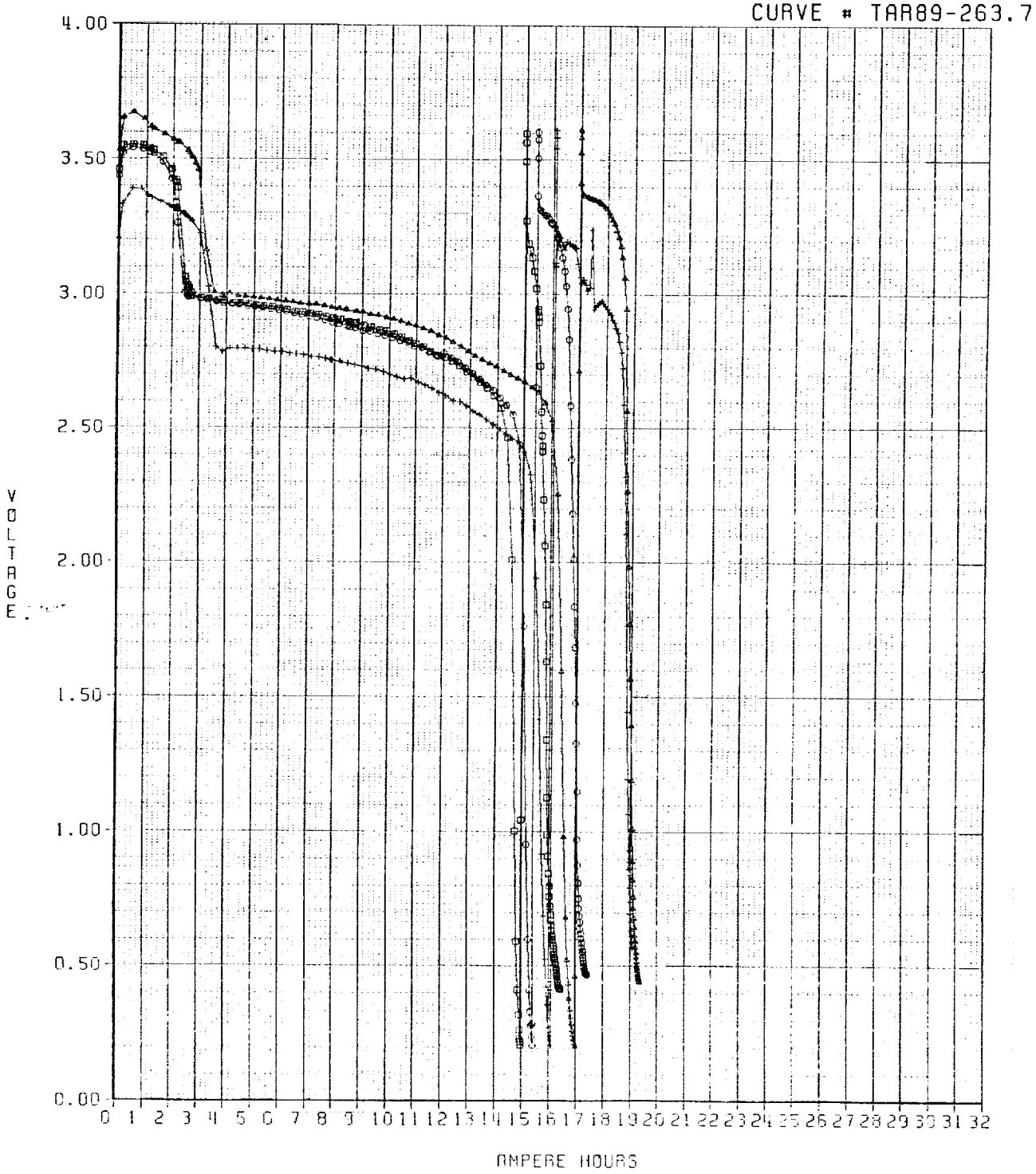
S/N 18353 □ D249C -10
S/N 18354 ⊙ E249A -4
S/N 18355 △ A299A -23
S/N 18356 + A299B -17

DISCHARGED AT -40°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 18AUG89
CURVE # TAR89-263.7



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DAY 299 THU, OCT 26 1989 3:15:23 PM

Figure 10

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

S/N 18403 □ A249A -35 S/N 18404 ⊙ B249A -11
S/N 18405 △ B249C -21 S/N 18406 + C249B -24
S/N 18407 × C249C -14 S/N 18408 ◇ D249A -32
DISCHARGED AT - 18°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

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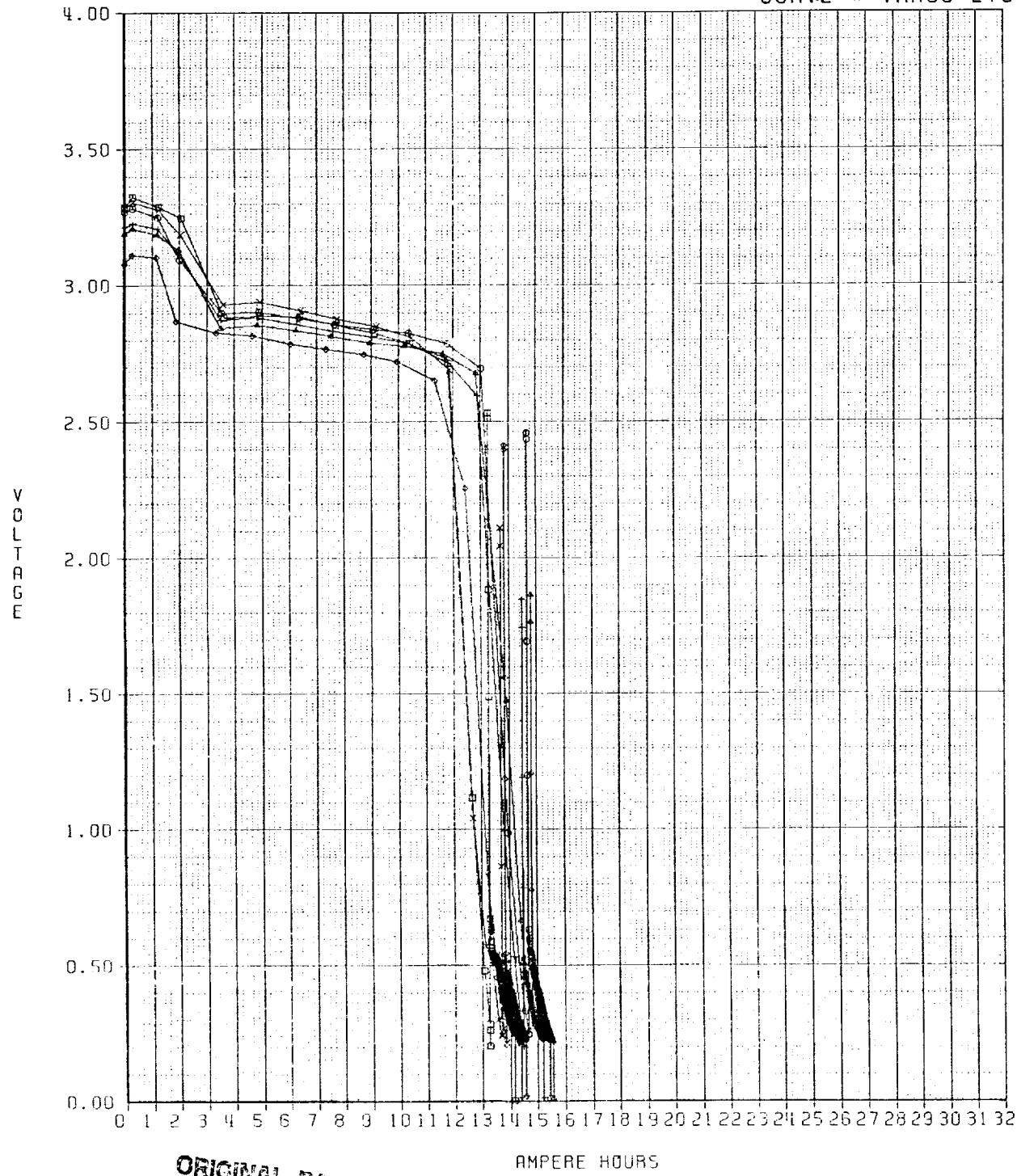
ON TEST 18AUG89
CURVE # TAR89-273



GPLOT (REV. 3.1)

DAY 299 THU, OCT 26 1989 10:00:33 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

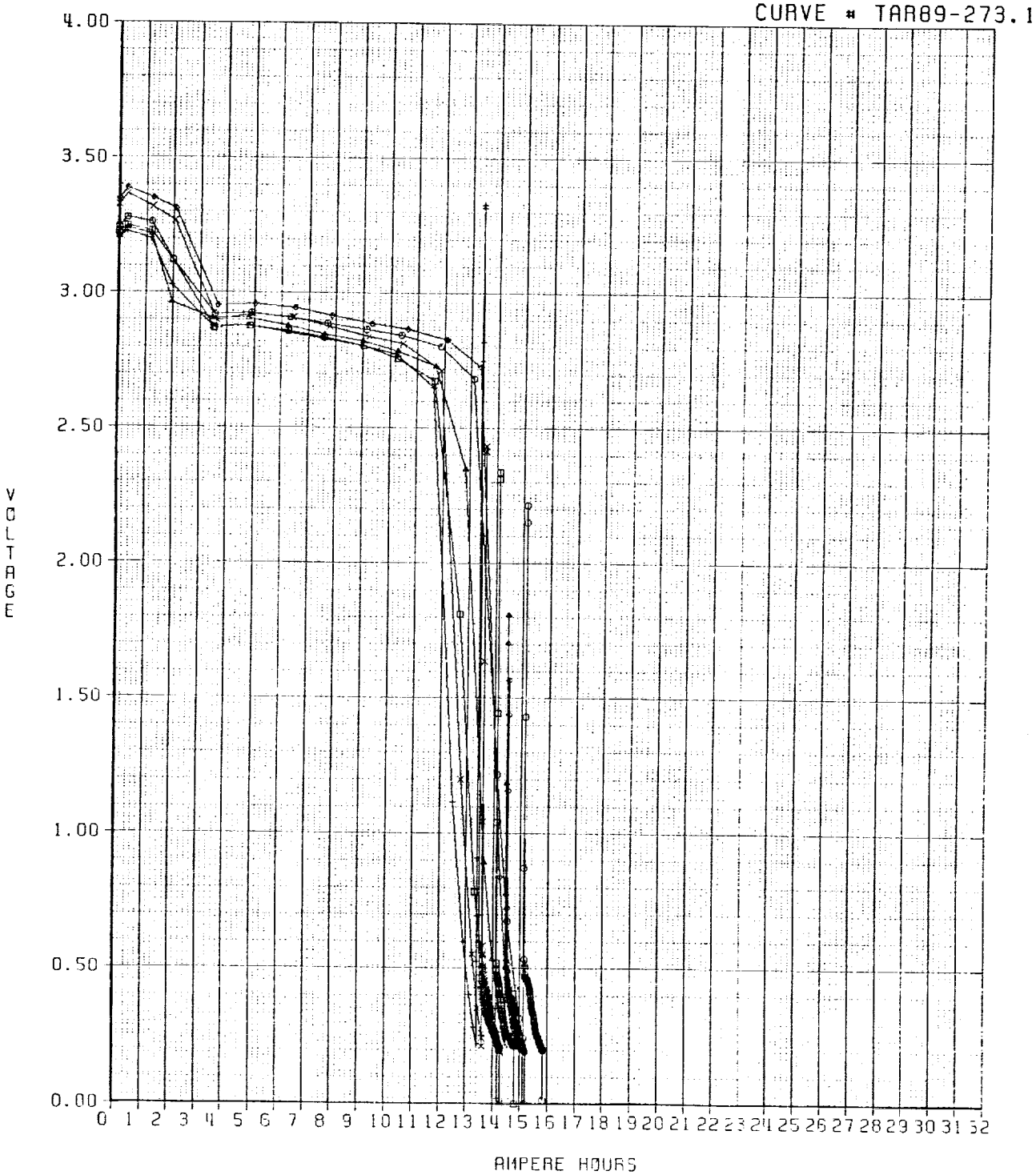
Figure 11

S/N 18409 ◫ D249B-17
S/N 18410 ⓘ D249C-12
S/N 18411 △ E249A-40
S/N 18412 + E249B-15
S/N 18413 X A299A-22
S/N 18414 ◇ A299B-34
DISCHARGED AT - 18°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 18AUG89
CURVE # TAR89-273.1



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 10:04:30 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

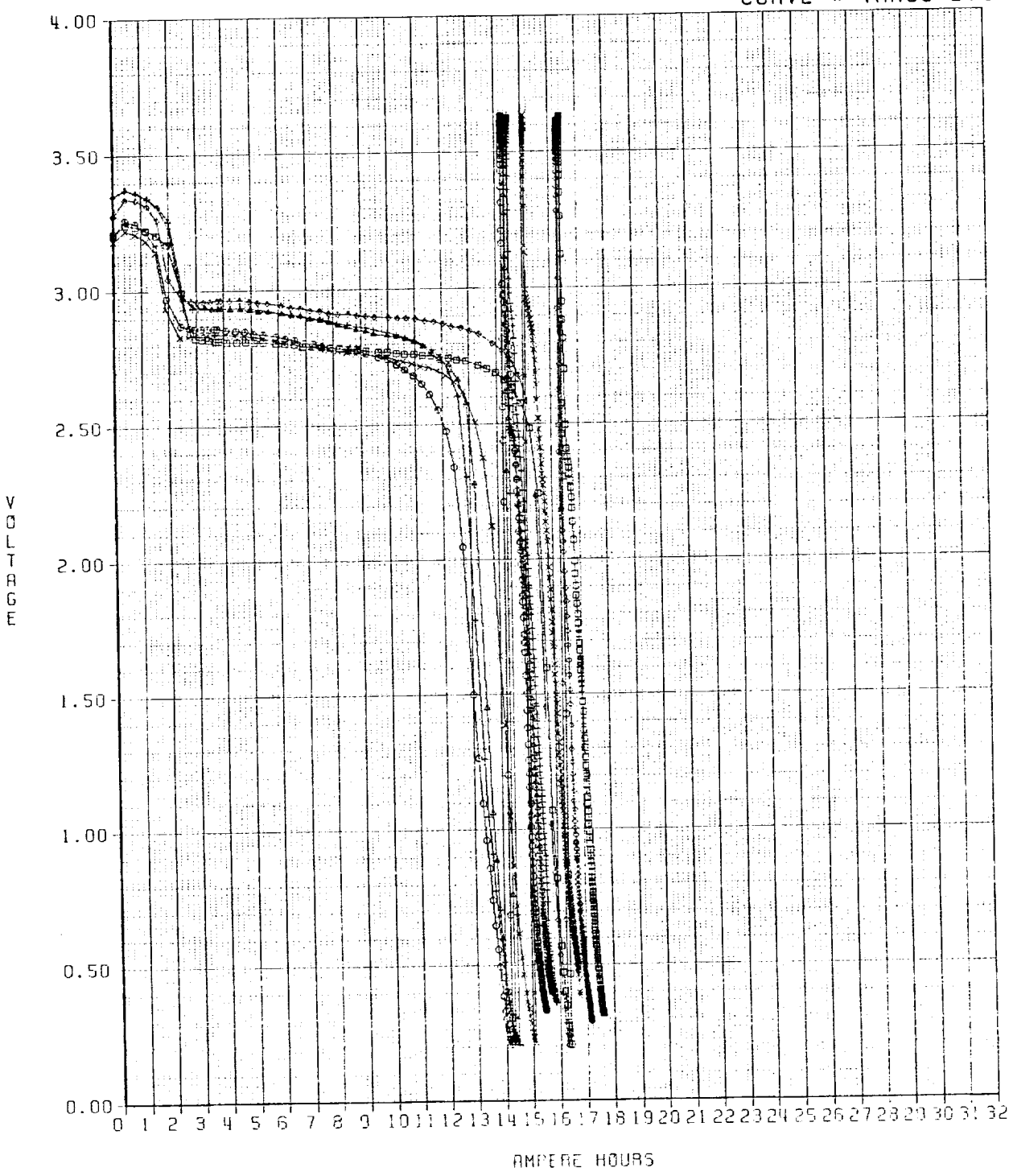
Figure 12

S/N 18415 ◻ A249A -31
S/N 18416 ⏀ B249A-22
S/N 18417 △ B249C -7
S/N 18418 + C249C-11
S/N 18419 × D249A -18
S/N 18420 ◇ D249B-15

DISCHARGED AT -18°C UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

ON TEST 23AUG89
CURVE # TAR89-274



GPLOT(REV. 3.1)

DAY 286 FRI, OCT 13 1989 3:11:55 PM

BCX 149DD - 382085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 13

S/N 18421 □ D249C-14 S/N 18422 ⏀ E249A -46
S/N 18423 △ A299A-39 S/N 18424 + A299B -22

DISCHARGED AT -18°C UNDER ∩ 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

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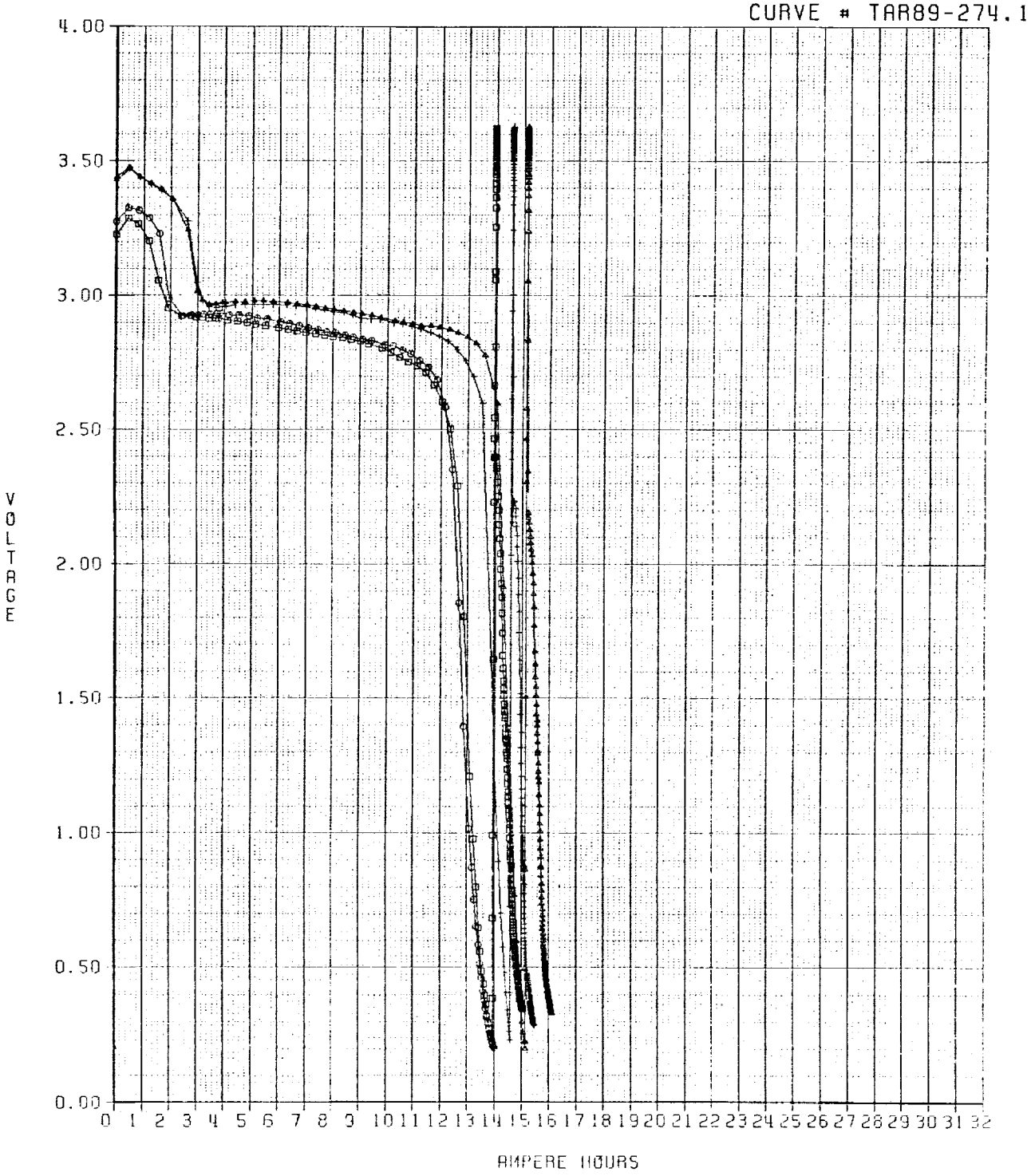
ON TEST 23AUG89
CURVE # TAR89-274.1



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 10:54:16 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 14

S/N 18285 □ A249A -12
S/N 18286 ⓘ B249A -48
S/N 18287 △ B249C -9
S/N 18288 + C249C -43
S/N 18289 × D249A -19
S/N 18290 ◇ D249B -43

DISCHARGED AT - 18°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

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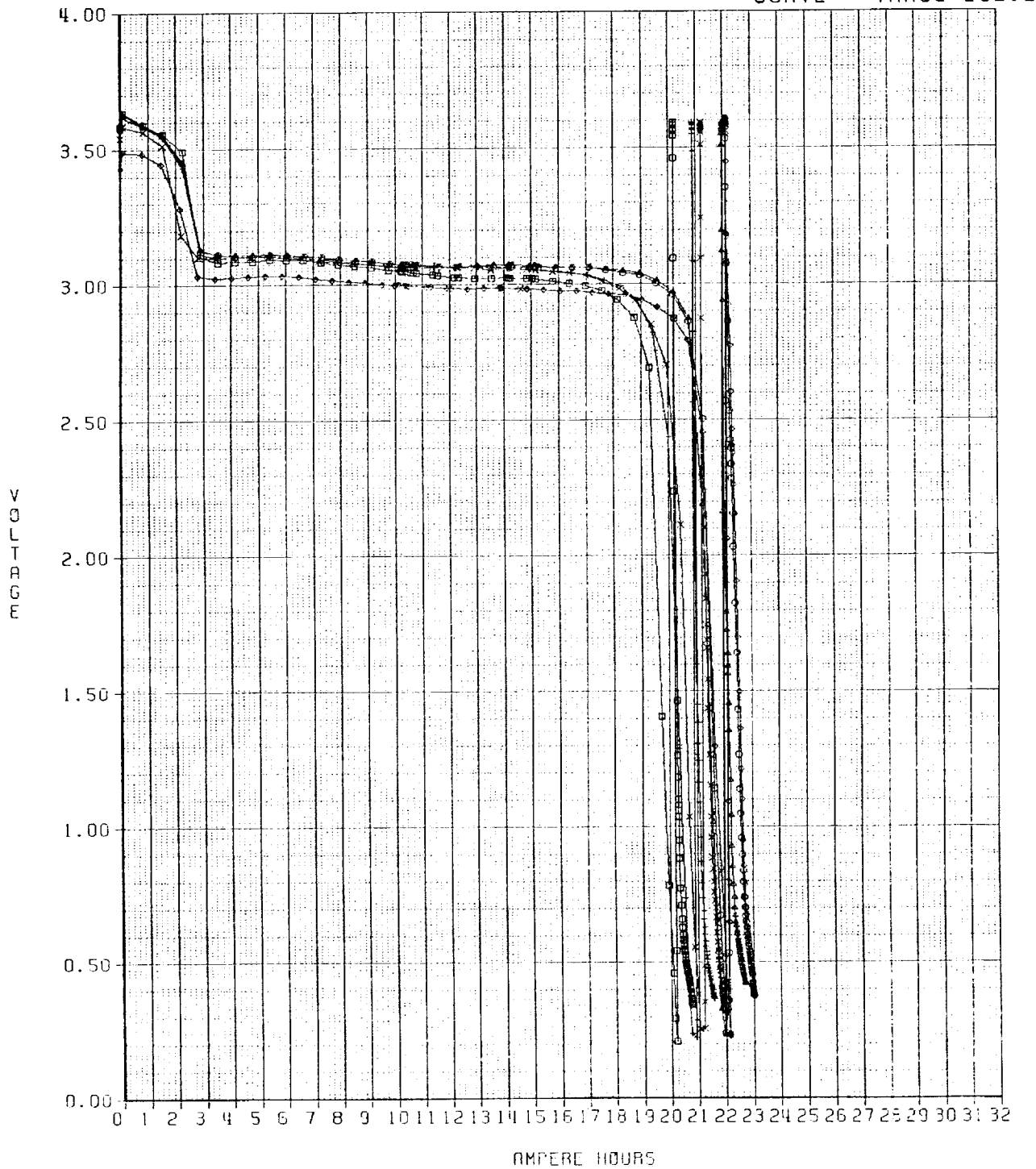
ON TEST 16JULY89
CURVE # TAR89-262.2



GPLOT (REV. 3.1)

DAY 299 THU, OCT 26 1989 12:52:17 PM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 15

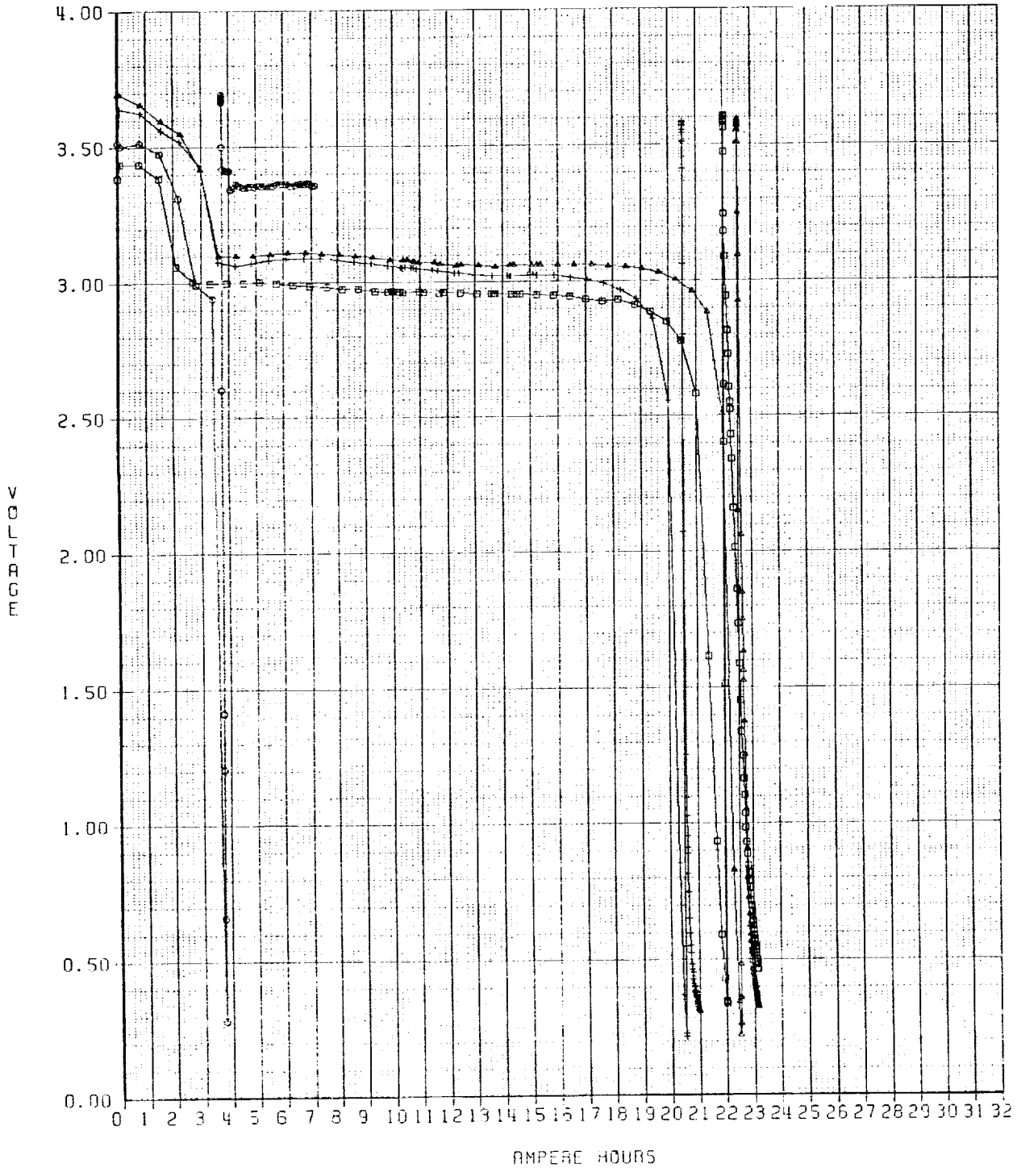
S/N 18291 ⊡ D249C-8
S/N 18293 △ A299A-8
S/N 18292 ⊙ E249A-36
S/N 18294 + A299B-3

DISCHARGED AT -18°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 16JULY89
CURVE # TAR89-262.3



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 12:54:34 PM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 16

S/N 18425 □ A249A -45
S/N 18426 ⏀ B249A -30
S/N 18427 △ B249C -31
S/N 18428 + C249C -36
S/N 18429 × D249A -13
S/N 18430 ◇ D249B -21

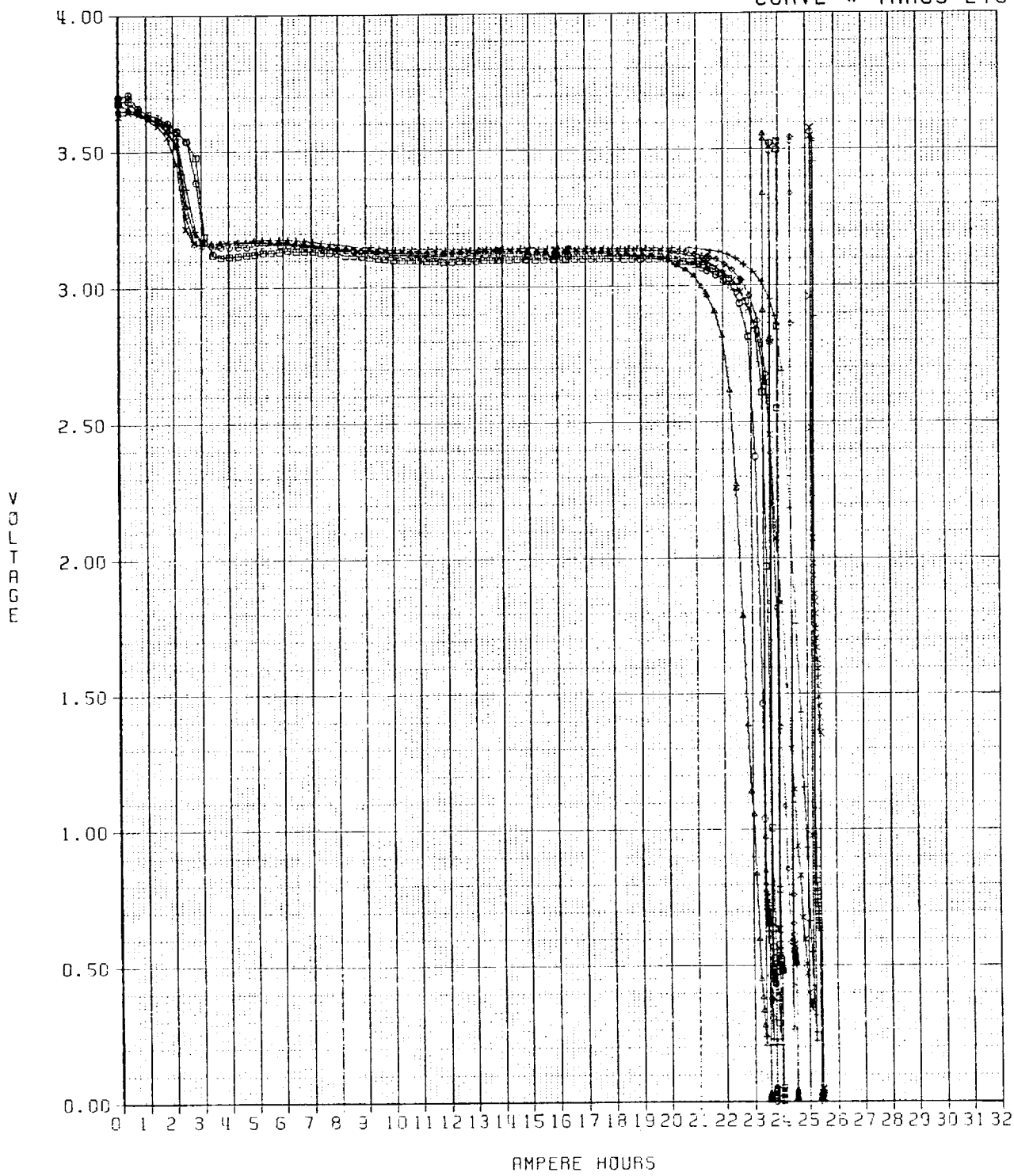
DISCHARGED AT -18°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION:

P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 19AUG89
CURVE # TAR89-275



BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 17

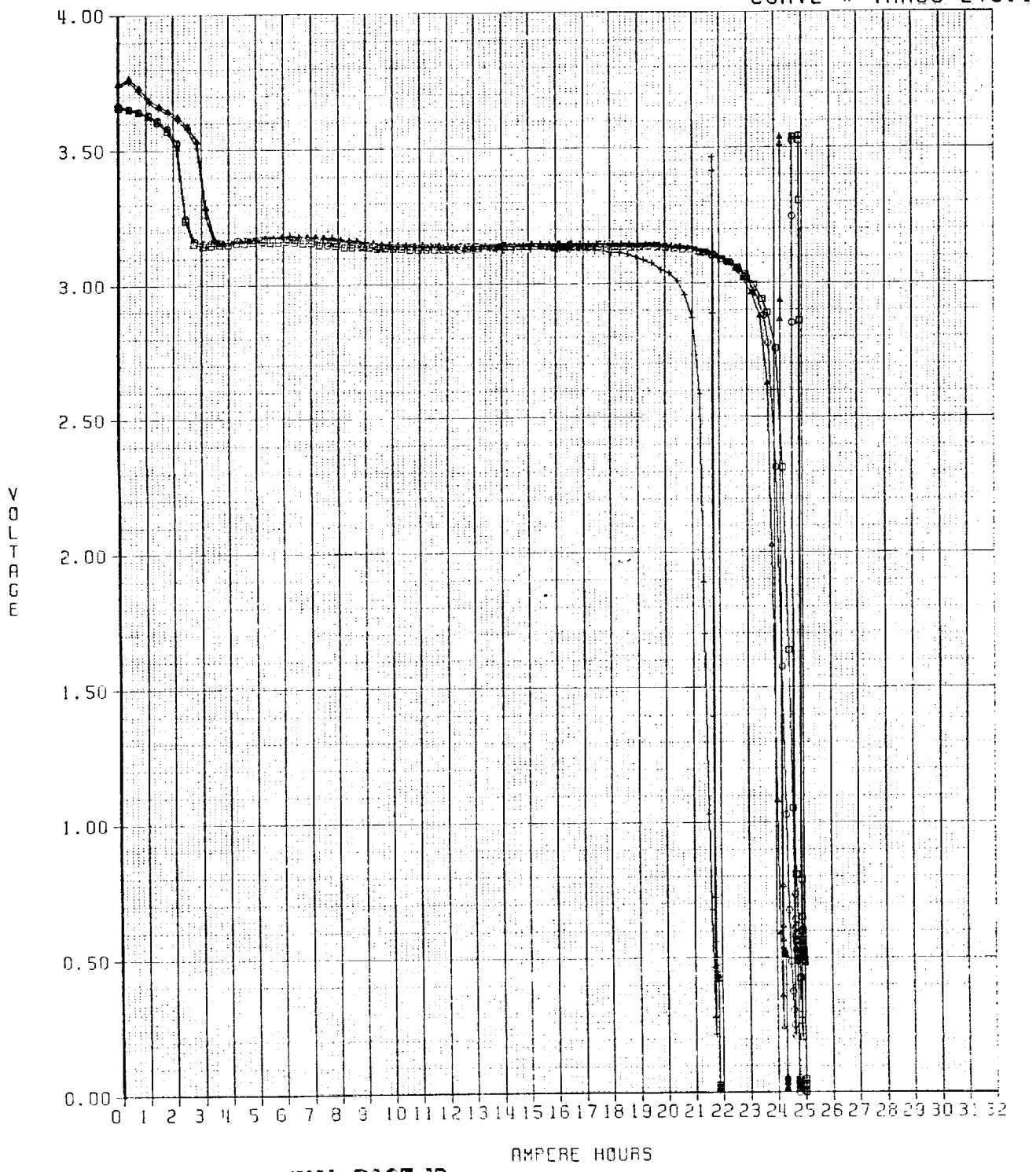
S/N 18431 □ D249C -18
S/N 18432 ⏀ E249A-24
S/N 18433 △ A299A -32
S/N 18434 + A299B-23

DISCHARGED AT -18°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 19AUG89
CURVE # TAR89-275.1



GPLOT (REV. 3.11)

DAY 299 THU, OCT 26 1989 2:55:16 PM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 18

S/N 18187 ☐ A249B-4 S/N 18188 ⊙ B249A -39
S/N 18189 △ B249B-42 S/N 18190 + C249B -30
S/N 18191 × C249C-28 S/N 18192 ◇ D249A -7
DISCHARGED AT ROOM TEMPERATURE UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

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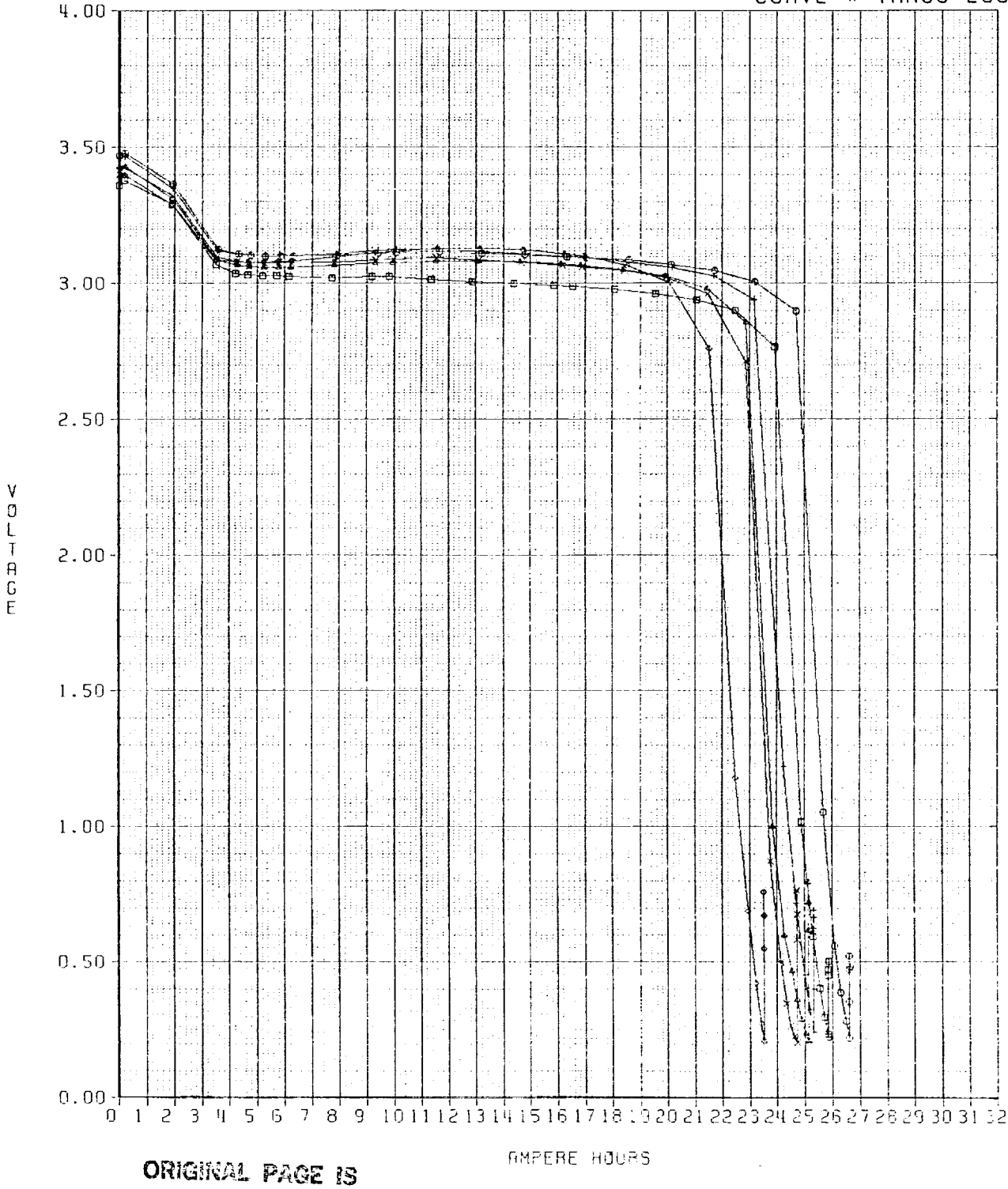
ON TEST 27JULY89
CURVE # TAR89-260



BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 19

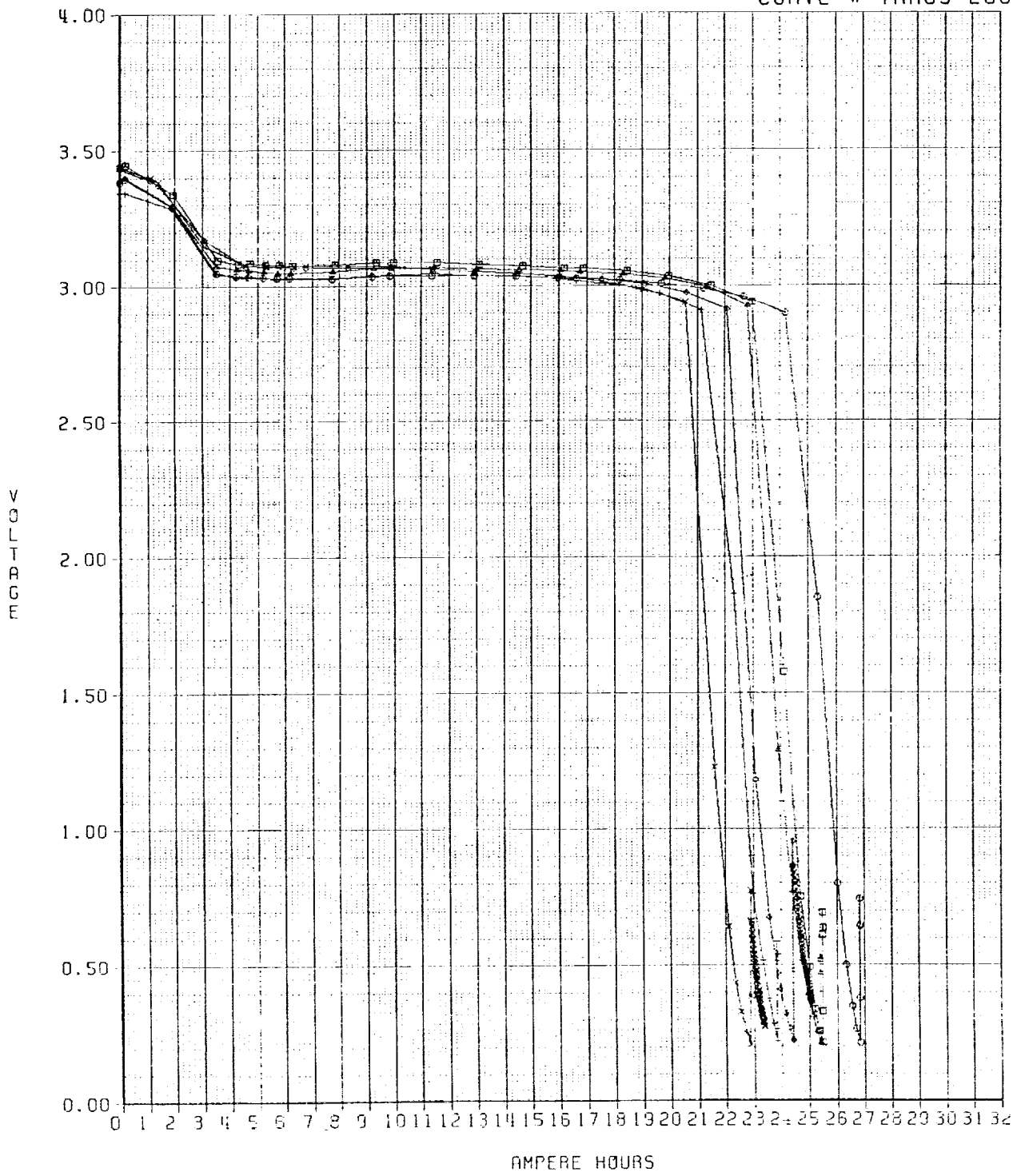
S/N 18193 □ D249B-32
S/N 18194 ⊙ D249C-23
S/N 18195 △ E249A-44
S/N 18196 + E249B-32
S/N 18197 × A299A-28
S/N 18198 ◇ A299B-16

DISCHARGED AT ROOM TEMPERATURE UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 27JULY89
CURVE # TAR89-260.1



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DAY 299 THU. OCT 26 1989 09:50:23 PM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 20

S/N 18231 ▯ A249B -19
S/N 18232 ⏀ B249A-45
S/N 18233 △ B249B -44
S/N 18234 + C249B-10
S/N 18235 × C249C -22
S/N 18236 ◇ D249A-17

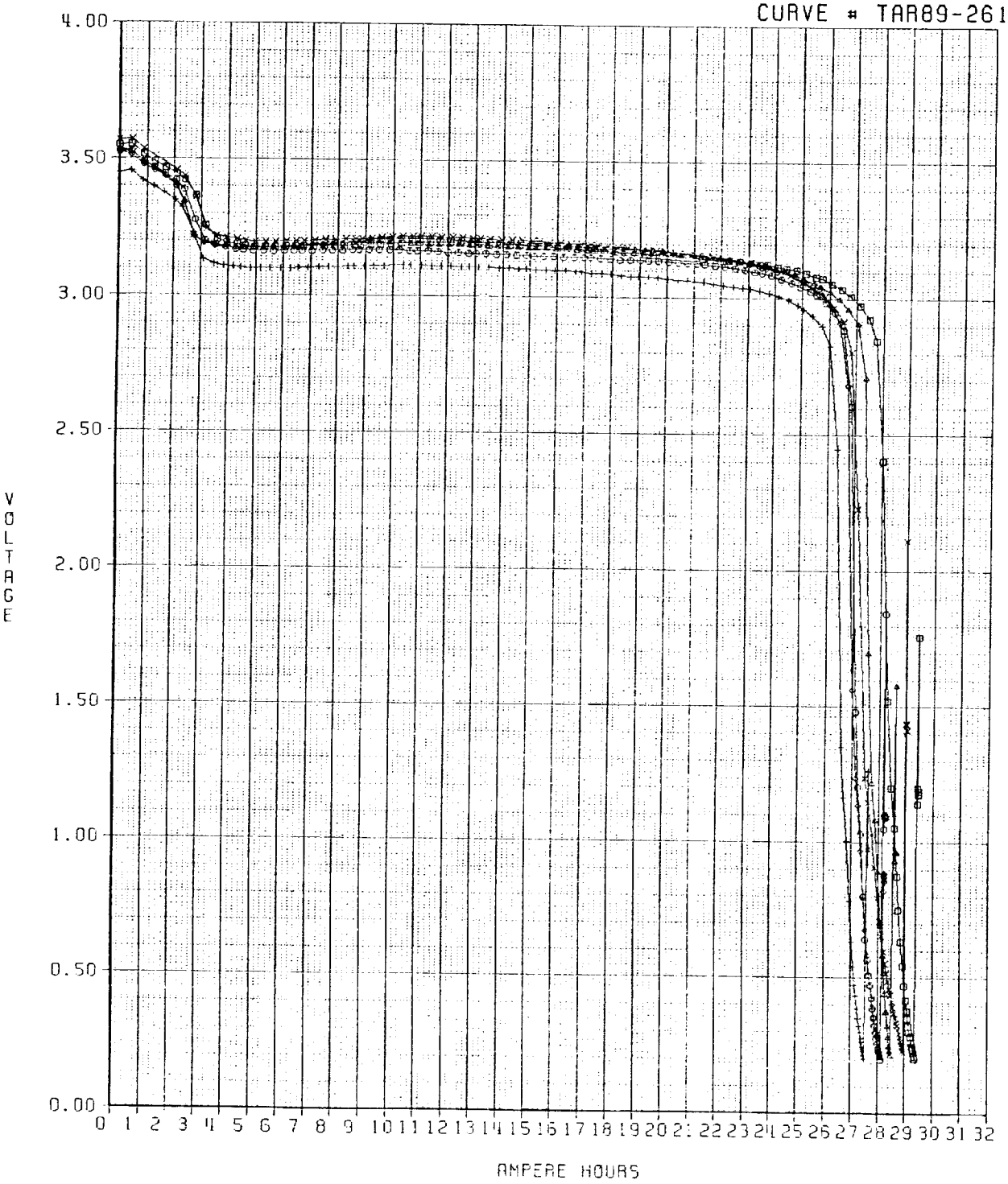
DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARG

DISTRIBUTION:

P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 27JULY89
CURVE # TAR89-261



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 10:45:42 AM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 21

S/N 18237 ☐ D249B -27 S/N 18238 ⓘ D249C -4
S/N 18239 △ E249A -14 S/N 18240 + E249B -28
S/N 18241 × A299A -12 S/N 18242A ◇ A299B -4
DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHAR(

DISTRIBUTION: P. KAEHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 27JULY89
CURVE # TAR89-261.1

GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 10:50:35 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

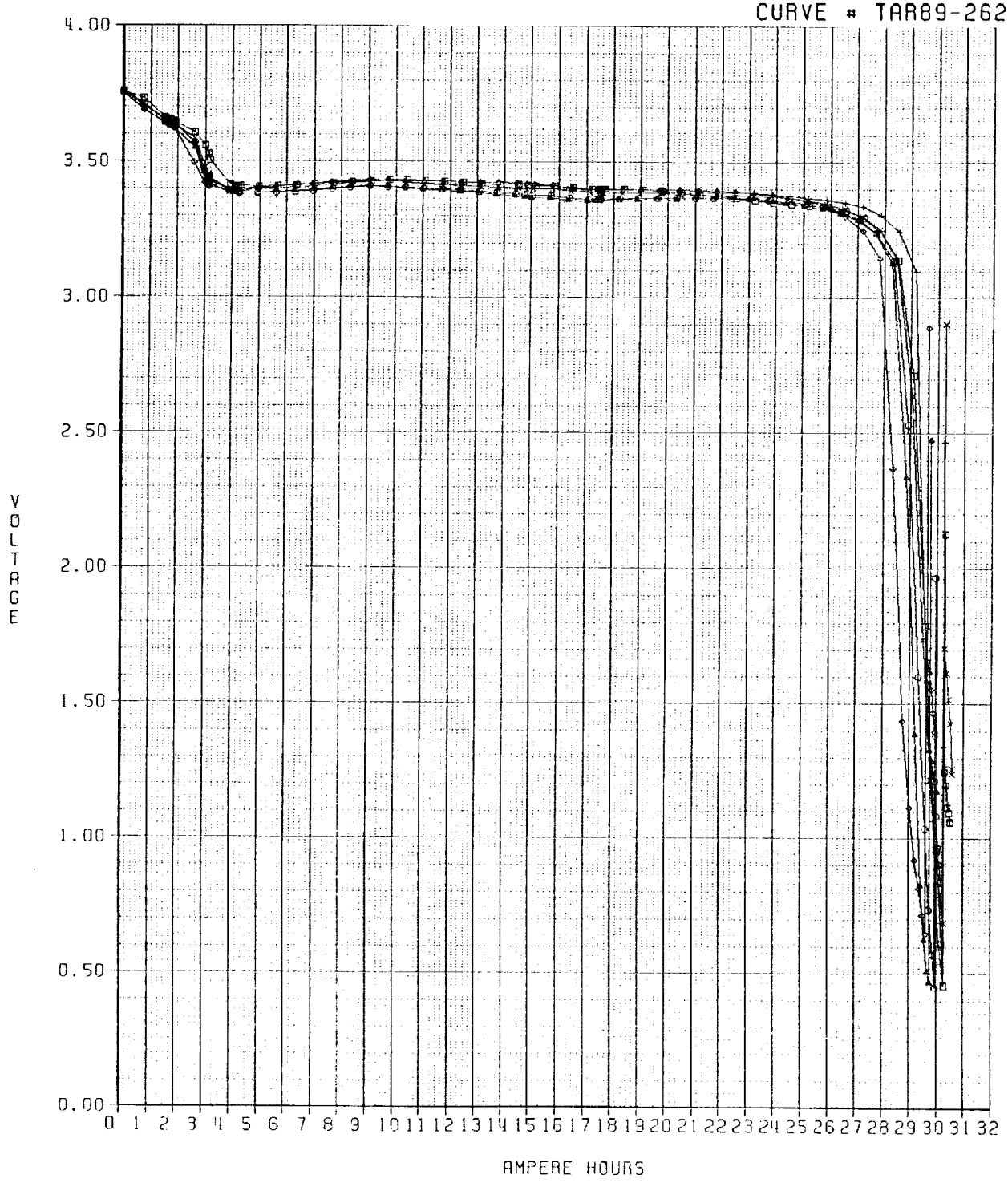
Figure 22

S/N 18273 □ A249B -34 S/N 18274 ○ B249A -15
S/N 18275 △ B249B -11 S/N 18276 + C249B -2
S/N 18277 × C249C -47 S/N 18278 ◇ D249A -11
DISCHARGED AT ROOM TEMPERATURE UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 25JULY89
CURVE # TAR89-262



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 12:45:48 PM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

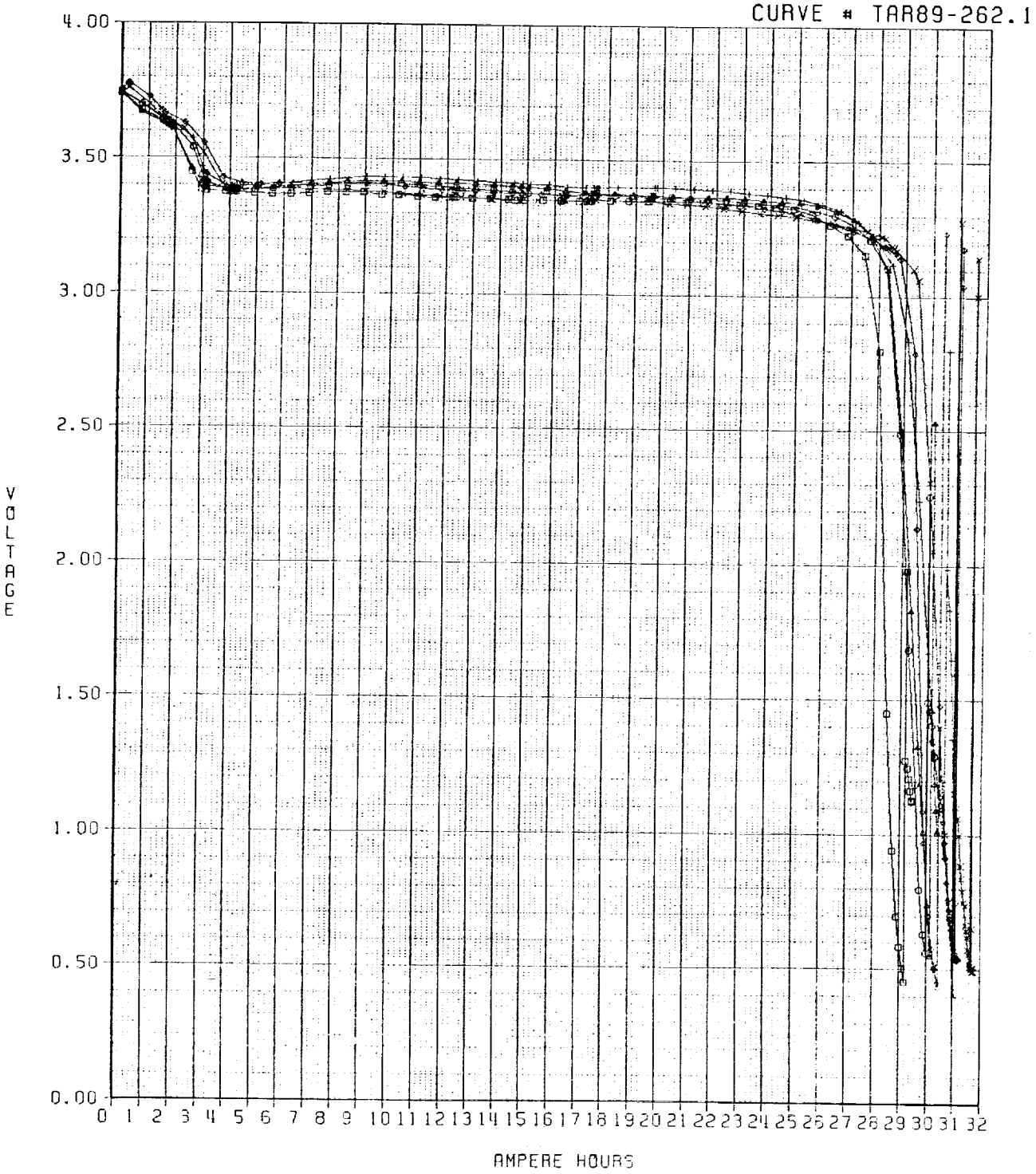
Figure 23

S/N 18279 ◫ D249B-34
S/N 18280 ⏀ D249C -10
S/N 18281 ⏃ E249A-23
S/N 18282 + E249B -18
S/N 18283 × A299A-20
S/N 18284 ◇ A299B -7
DISCHARGED AT ROOM TEMPERATURE UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 25JULY89
CURVE # TAR89-262.1



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 12:49:00 PM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

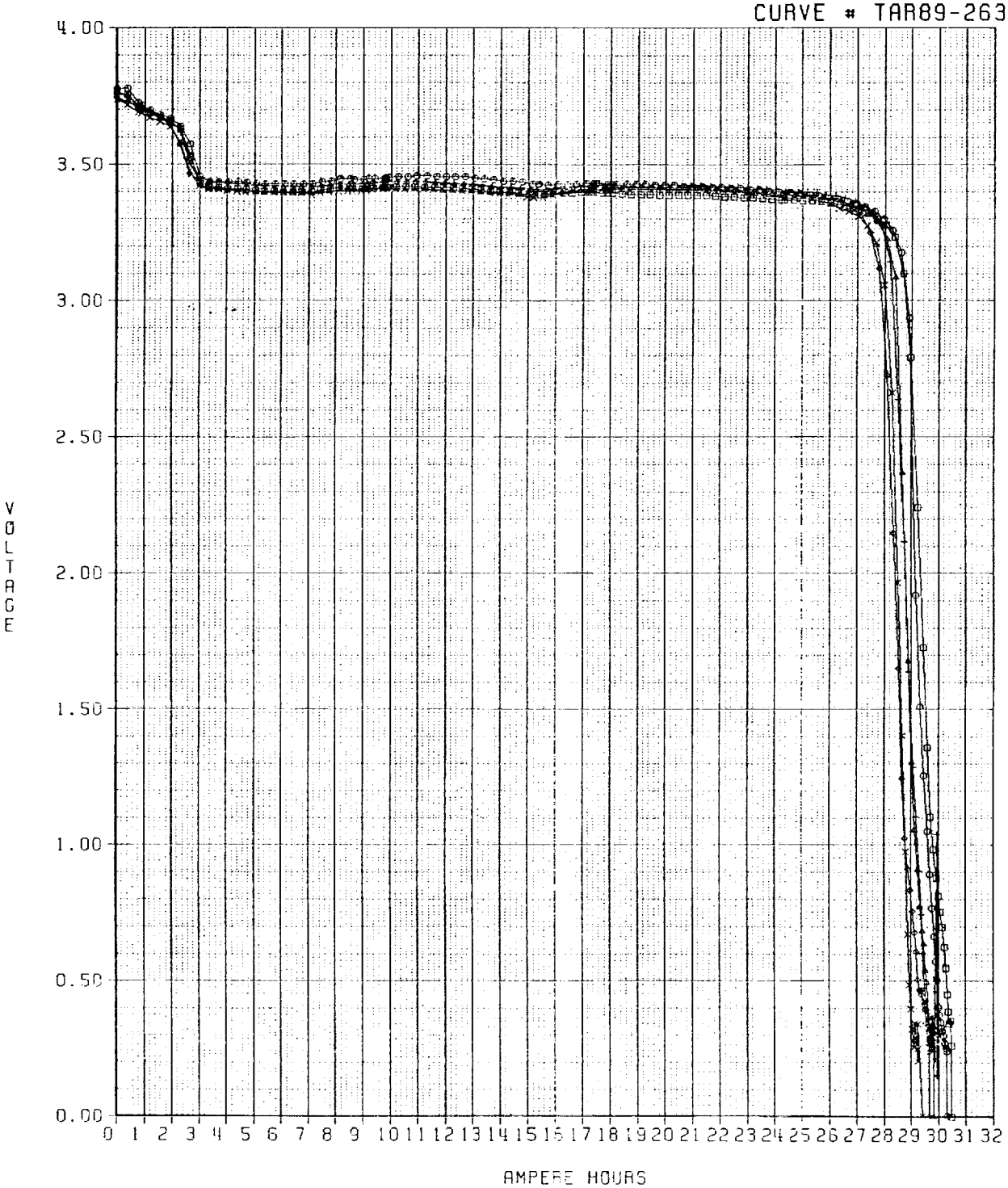
Figure 24

S/N 18315 □ A249B -40 S/N 18316 ⊙ B249A -2
S/N 18317 △ B249B -37 S/N 18318 + C249B -19
S/N 18319 × C249C -10 S/N 18320 ◇ D249A -36
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 09AUG89
CURVE # TAR89-263



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 2:35:38 PM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

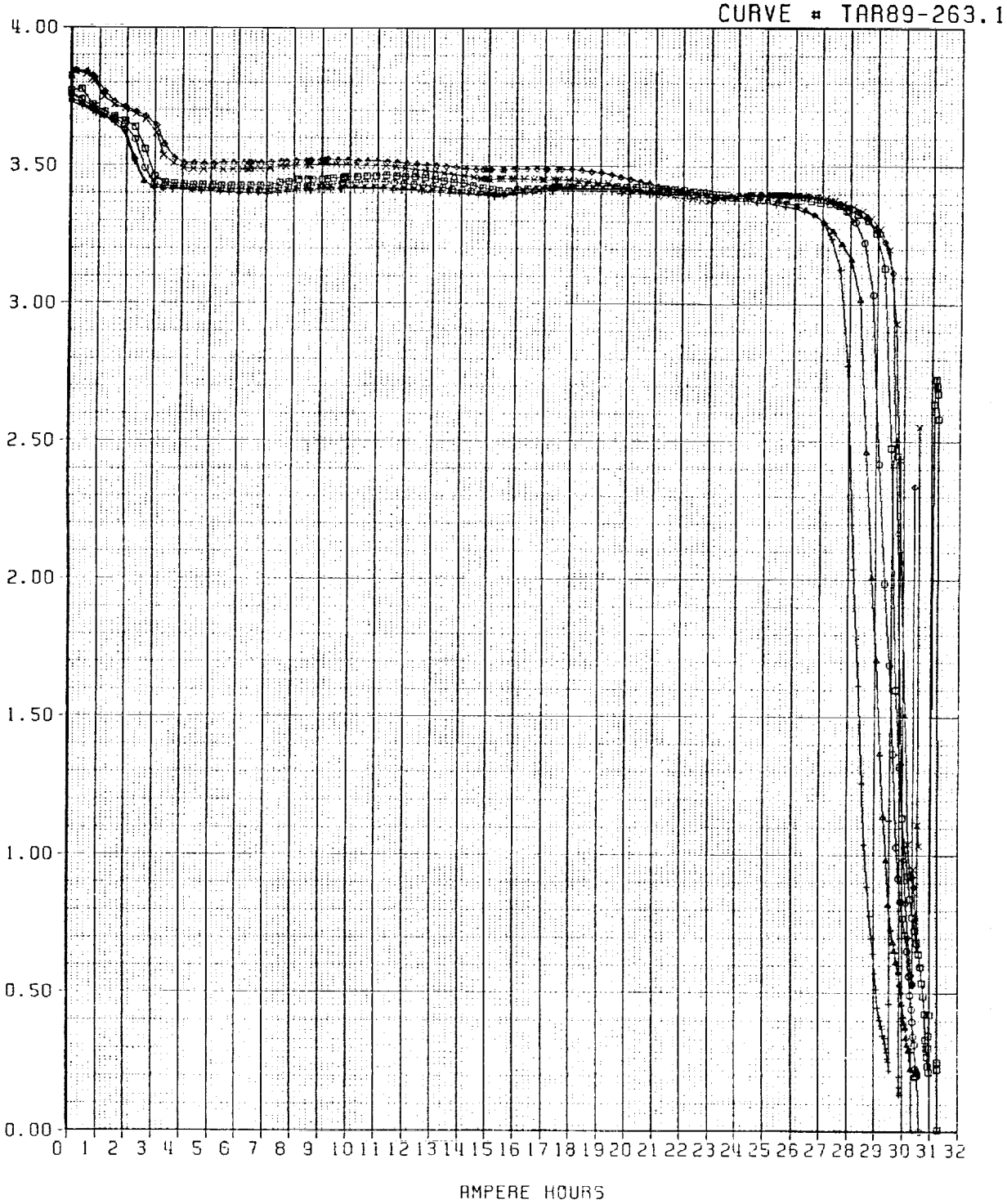
Figure 25

S/N 18321 □ D249B -24 S/N 18322 ⊙ D249C -13
S/N 18323 △ E249A -26 S/N 18324 + E249B -39
S/N 18325 × A299A -35 S/N 18326 ◇ A299B -13
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION:
P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 09AUG89
CURVE # TAR89-263.1



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 2:39:29 PM

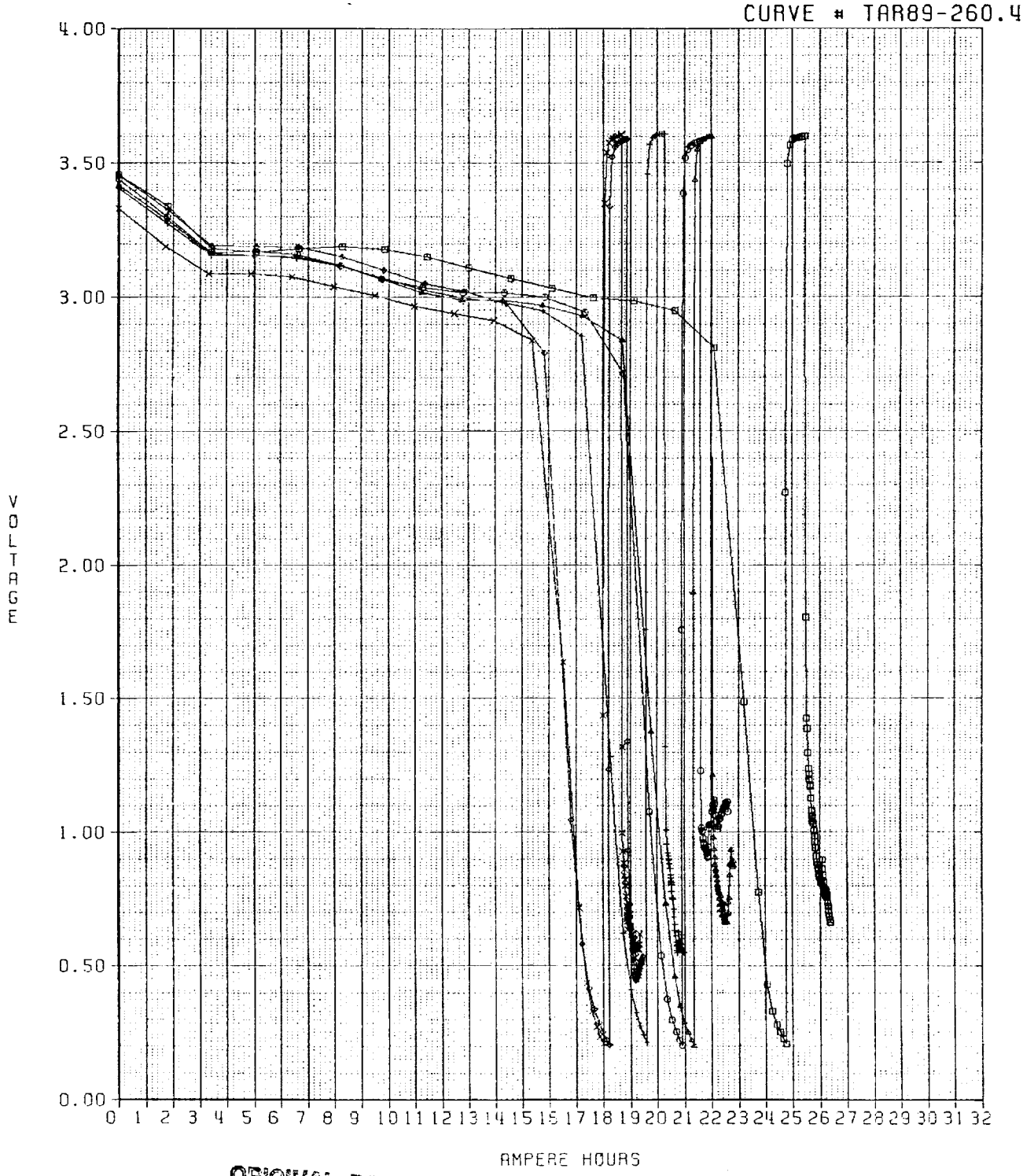
BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 26

S/N 18211 □ A249A -10 S/N 18212 ⏀ B249B-12
S/N 18213 △ B249C -37 S/N 18214 + C249C-46
S/N 18215 × D249A -5 S/N 18216 ◇ D249B-4
DISCHARGED AT 71°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

ON TEST 14AUG89
CURVE # TAR89-260.4



BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 27

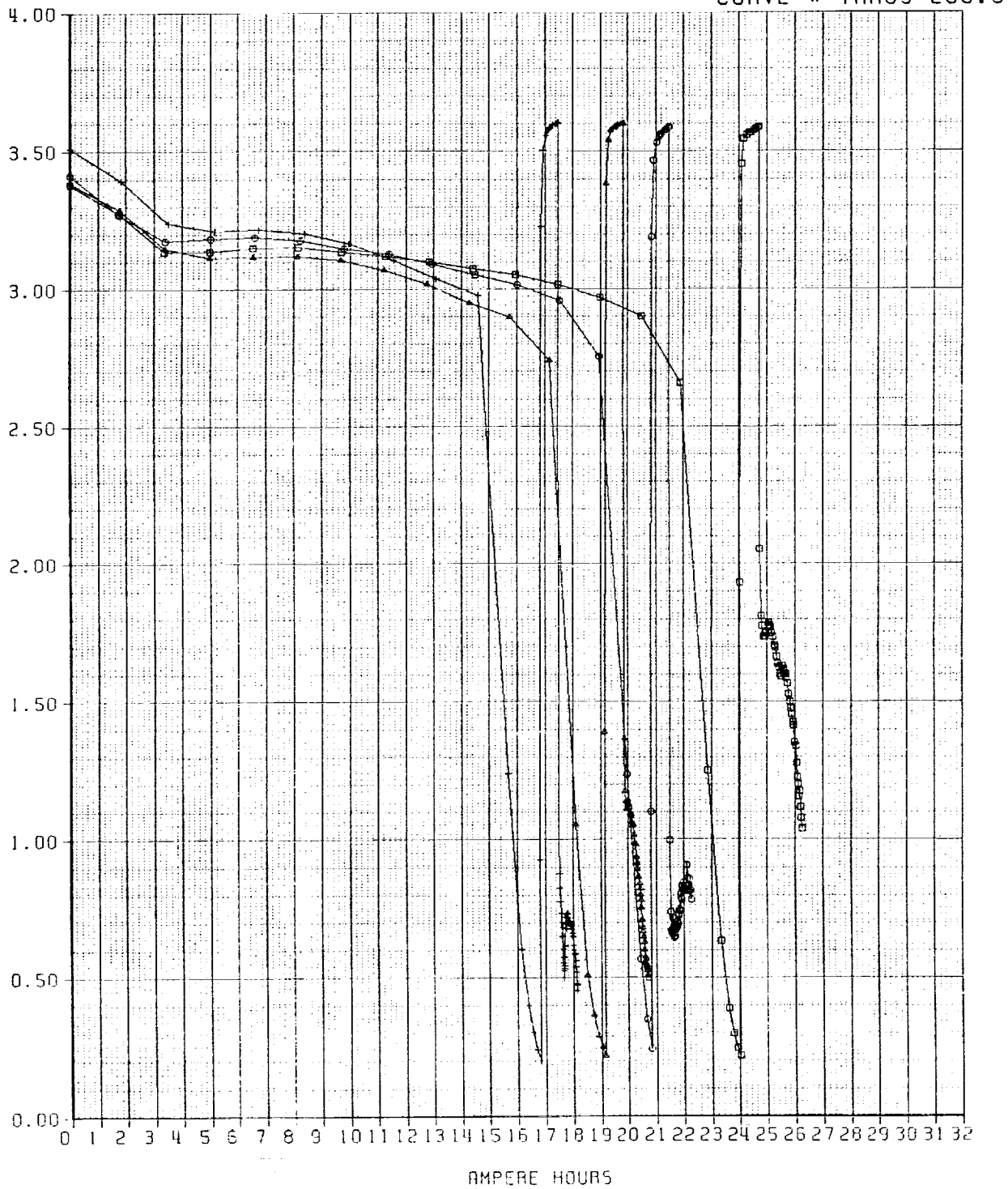
S/N 18217 □ D249C -39
S/N 18218 ⏱ E249A -31
S/N 18219 △ A299A -10
S/N 18220 + A299B -20

DISCHARGED AT 71°C UNDER A 1 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14AUG89
CURVE # TAR89-260.5



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GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 10:10:16 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

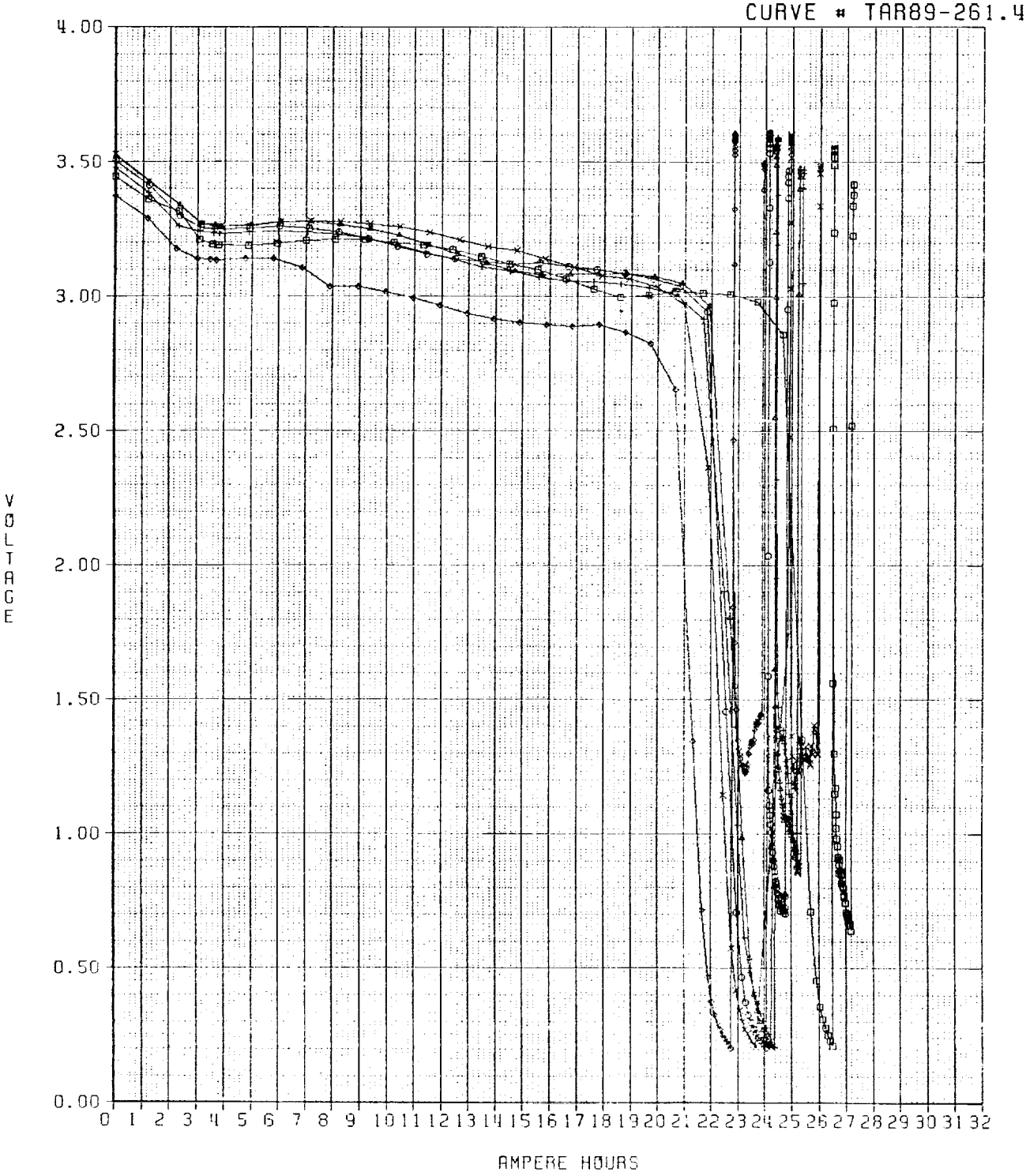
Figure 28

S/N 18253 □ A249A -24 S/N 18254 ⊙ B249B -31
S/N 18255 △ B249C -47 S/N 18256 + C249C -17
S/N 18257 × D249A -34 S/N 18258 ◇ D249B -26
DISCHARGED AT 71°C UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 14AUG89
CURVE # TAR89-261.4



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26 1989 10:57:59 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 29

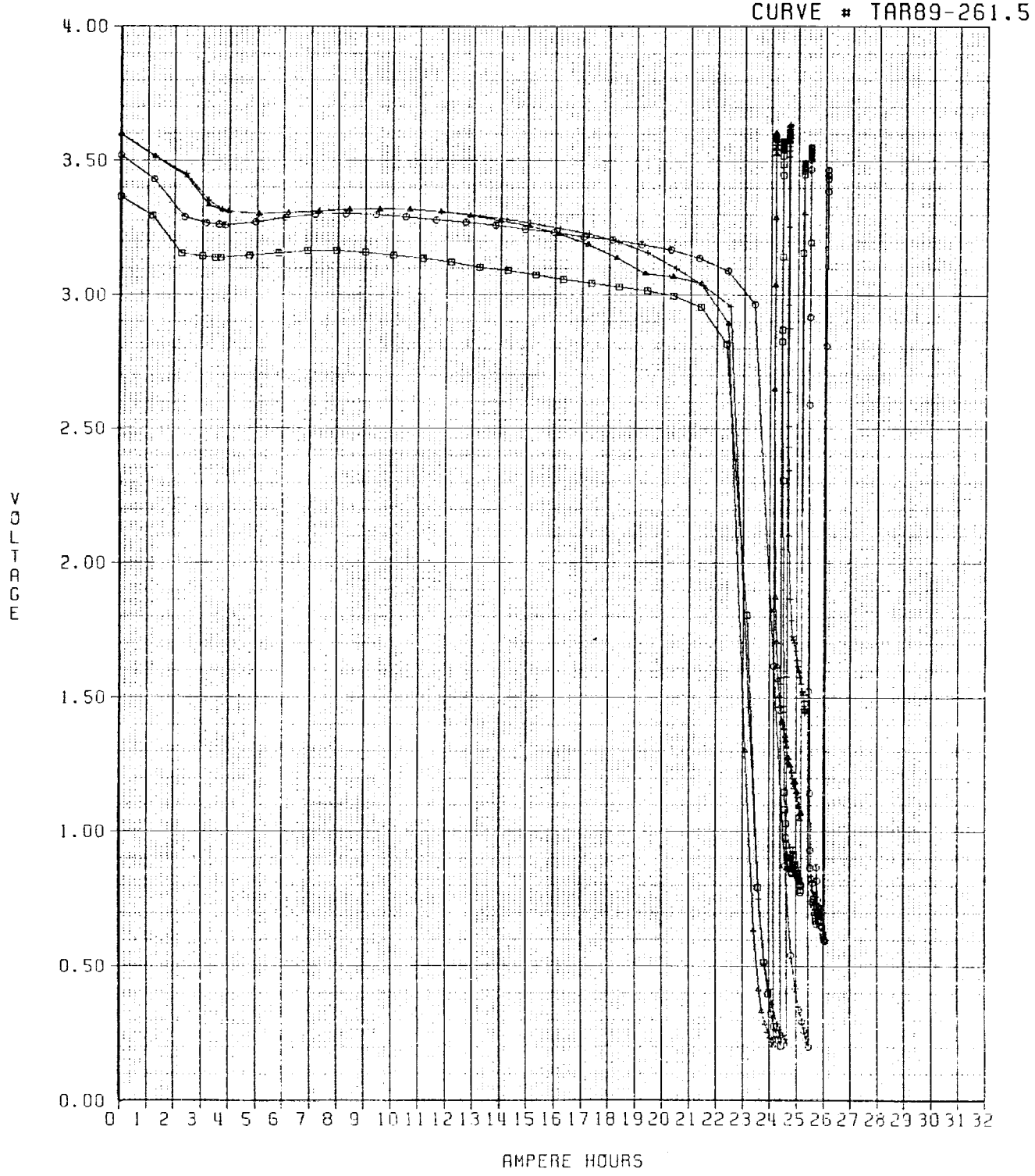
S/N 18259 □ D249C -1
S/N 18260 ⏲ E249A -41
S/N 18261 △ A299A -5
S/N 18262 + A299B -41

DISCHARGED AT 71°C UNDER A 1.5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 16AUG89
CURVE # TAR89-261.5



GPLOT(REV. 3.1)

DAT 299 THU, OCT 26 1989 11:03:23 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

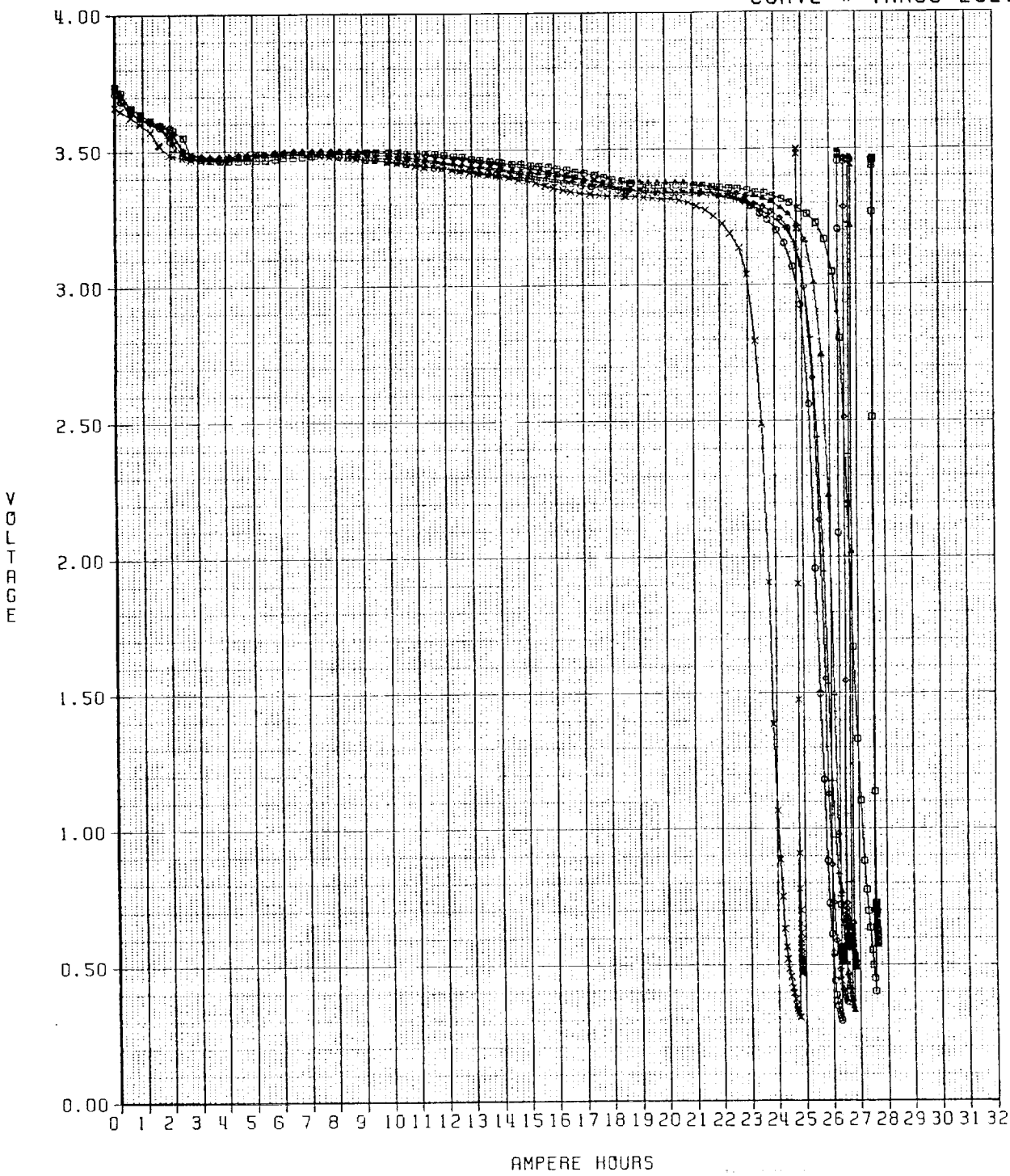
Figure 30

S/N 18295 □ A249A -7
S/N 18296 ⊙ B249B -18
S/N 18297 △ B249C -14
S/N 18298 + C249C -21
S/N 18299 × D249A -3
S/N 18300 ◇ D249B -9
DISCHARGED AT 71°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL, B. WEBSTER, S. EBEL, R. SAMIT, D. SIEMINSKI, R. STINEBRING, R. NEUMANN, S. MEYER

WG

ON TEST 29AUG89
CURVE # TAR89-262.4



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 12:57:44 PM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

S/N 18301 □ D249C -17 S/N 18302 ⏀ E249A -43
S/N 18303 △ A299A -34 S/N 18304 + A299B -15

DISCHARGED AT 71°C UNDER A 5 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

ON TEST 29AUG89
CURVE # TAR89-262.5

GPLOT(REV. 3.1) DAT 299 THU, OCT 26 1989 3:00:44 PM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 32

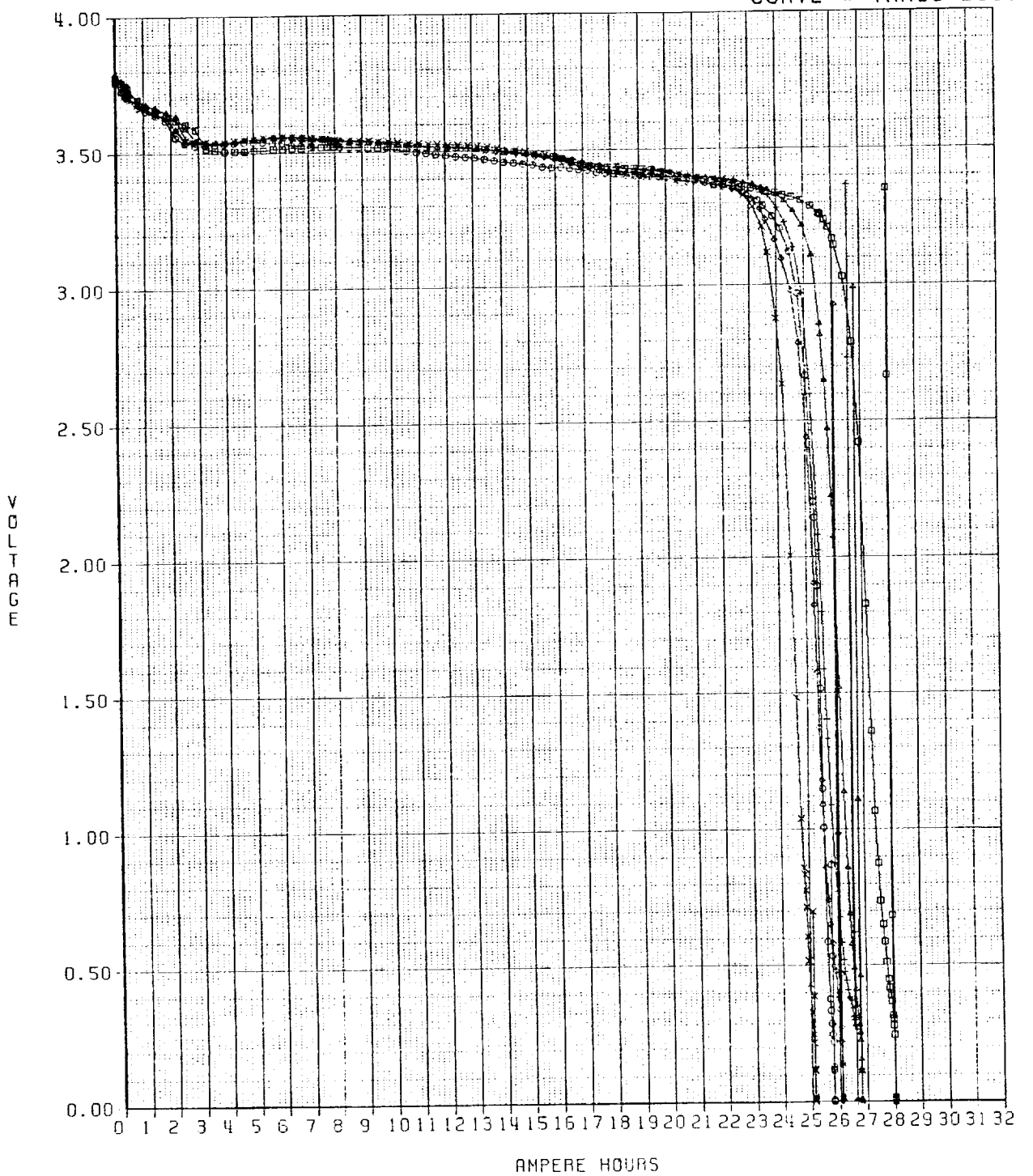
S/N 18337 □ A249A -5
S/N 18338 ⓘ B249B -16
S/N 18339 △ B249C -25
S/N 18340 + C249C -9
S/N 18341 × D249A -31
S/N 18342 ◇ D249B -13

DISCHARGED AT 71°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 25AUG89
CURVE # TAR89-263.4



GPLOT(REV. 3.1)

DAY 299 THU, OCT 26, 1989 3:00:40 PM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
CAPACITY DISCHARGE

Figure 33

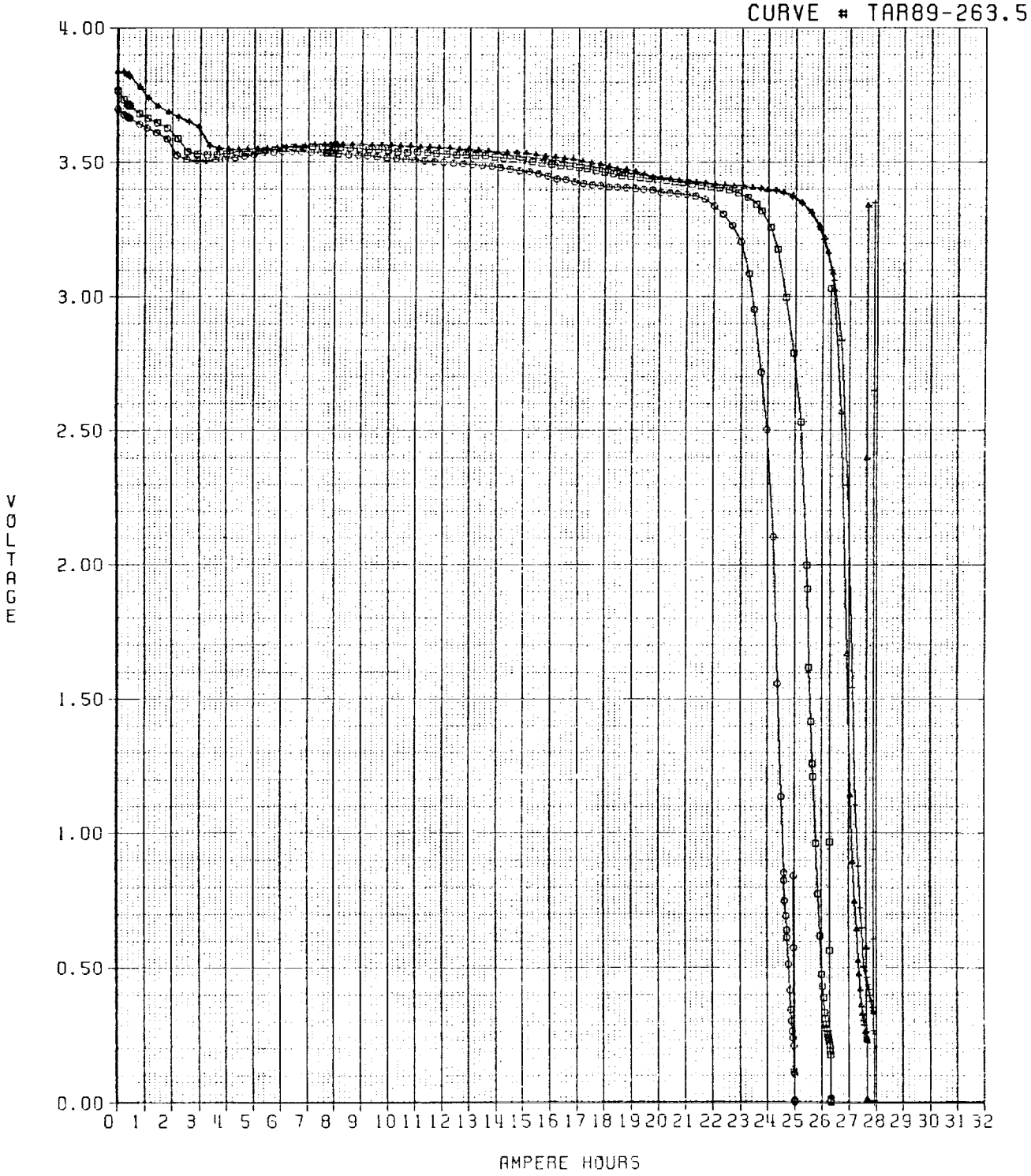
S/N 18343 ☐ D249C -47
S/N 18345 △ A299A -47
S/N 18344 ⊙ E249A -2
S/N 18346 + A299B -6

DISCHARGED AT 71°C UNDER A 10 OHM LOAD/20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 25AUG89
CURVE # TAR89-263.5



GPLOT(REV. 3.1)

DAY 299 THU. OCT 26 1989 3:06:09 PM

Average Performance of Li/BCX DD Cells vs. Discharge Rate

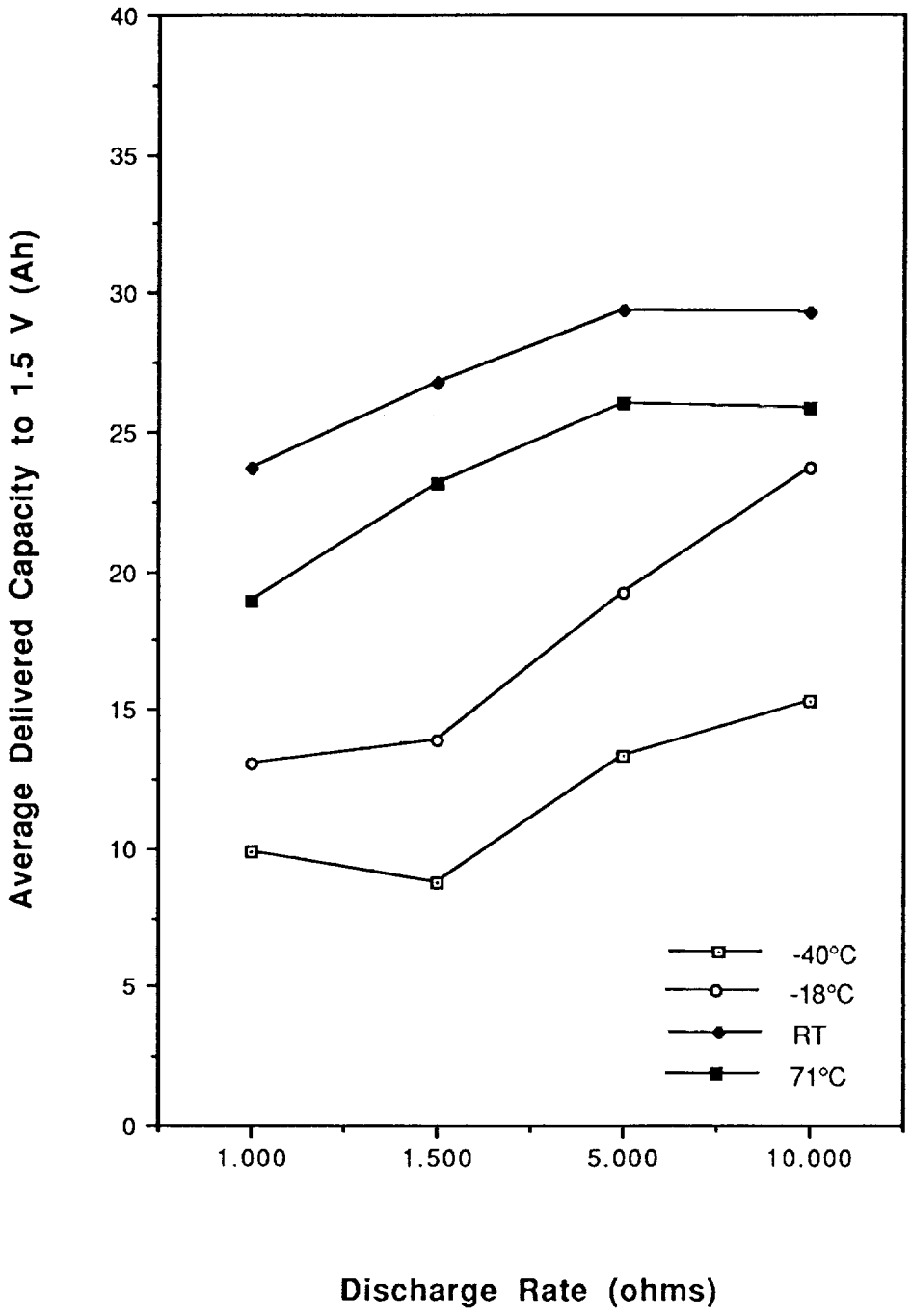


Table 4: Cell Peak Temperatures during Performance Testing

Serial Number	Test Temperature (°C)	Discharge Rate (ohms)	Peak Temperature (°C)
18216	71	1.0	89.8
18220	71	1.0	89.1
18258	71	1.5	85.0
18262	71	1.5	75.5
18300	71	5.0	77.0
18304	71	5.0	77.5
18342	71	10.0	76.6
18346	71	10.0	76.6
18192	29	1.0	67.3
18196	29	1.0	52.5
18236	31	1.5	45.3
18240	31	1.5	47.4
18282	32	5.0	37.4
18278	32	5.0	40.0
18320	28	10.0	32.1
18324	28	10.0	31.0
18414	-18	1.0	9.6
18408	-18	1.0	9.6
18420	-18	1.5	-4.0
18424	-18	1.5	-1.0
18290	-18	5.0	-10.0
18294	-18	5.0	-9.3
18430	-18	10.0	-12.5
18434	-18	10.0	-12.5
18310	-40	1.0	-3.3
18230	-40	1.0	-1.3
18268	-40	1.5	-22.8
18272	-40	1.5	-25.0
18226	-40	5.0	-15.0
18314	-40	5.0	-29.5
18352	-40	10.0	-33.8
18356	-40	10.0	-33.3

5. Abuse Testing (Task 4)

5.1 Short Circuit Tests

Uninsulated cell short circuit tests were conducted on a total of 51 cells under resistances of 0.5 ohms, 0.1 ohms, or 0.05 ohms; with initial cell temperatures of room temperature or 71°C. The minimum resistance which would not fuse internal plate tab connections was estimated to be 0.05 ohms. However, comprehensive testing would be required in order to determine this exact value. Cells were tested horizontally on a wooden block in order to insulate them from the test oven. Cell voltage, current, and temperature were measured for these tests such that a precise measurement of the heat generated during the short circuit condition could be calculated. Cell temperature was monitored by attaching thermocouples to each cell. The termination of the short circuit test was defined as a decrease in cell temperature for a period of at least 15 minutes.

Test parameters and results are presented in Short Circuit Test Report 90-014 which appears in Appendix E. Cells that were tested at room temperature under 0.5 ohms, and cells tested at 71°C under 0.5 ohms did not evidence any physical changes. Two cells (SN 32/A299B and SN 31/C249C) that were tested at room temperature under 0.1 ohms evidenced a loss of internal continuity indicating that the internal leads may have fused. Both of these cells were x-rayed and destructively analyzed. Results of the destructive analyses are presented in the Quality Control Department Destructive Analysis Reports which appear in Appendix F. Both x-ray and destructive analysis results confirmed that internal leads had fused. The remainder of the cells from this group did not evidence any physical changes. Cells that were tested at 71°C under 0.1 ohms evidenced case swelling and or rupture, and therefore testing was discontinued. One cell that was tested at room temperature under 0.05 ohms evidenced a loss of internal continuity while the remainder of the cells from this group were not affected physically or exhibited slight case swelling. Five of the six cells that were tested at 71°C under 0.05 ohms exhibited a loss of internal continuity, while one cell from this group ruptured approximately 10.5 minutes after the short was applied. In conclusion, loss of internal continuity occurred in cells that were short circuit tested at room temperature under 0.1 or 0.05 ohms, and cells that were short circuit tested at 71°C under 0.05 ohms.

The temperature profile inside a cell during short circuit has not been well established. Thus, the correlation between external case temperature and the temperature inside a cell at any given location is not known. It is possible that the internal temperature of a cell may exceed the external cell case temperature by several degrees. This provides some explanation as to how a cell with a skin temperature of only 149.5°C could rupture as did SN 20/B249A. Test results indicate that three cells experienced cell case temperatures of >186°C but did not rupture. This phenomenon has been observed in other BCX models. It has been postulated that molten lithium forms a pool in the cell case without causing a violent reaction. This may be related to the state of discharge of the cell and/or the orientation of the cell during the short circuit condition. As this is an intermittent occurrence, further work would need to be performed in order to gain a better understanding of this phenomenon.

Cells that were not damaged or destroyed were discharged at room temperature under 20 ohm loads following short circuit testing. Individual and average cell capacities to 3.0, 2.5, 2.0, and 1.5 volts are presented in Table 5 along with calculations of standard deviation. Discharge curves are shown in Figures 35 - 42.

For three cells per rate/temperature combination, the total heat generated during the short circuit condition was calculated by integrating the current versus time curve and multiplying this value by the instantaneous voltage drop as indicated in equation (1). Integration of the current versus time curve (amps vs. seconds) yields capacity in amp-seconds. Total energy in the form of joules (volt-amp-seconds) was obtained by multiplying the capacity (amp-seconds) by the change in voltage (volts). The change in voltage (ΔV) was determined by subtracting the short circuit voltage (V_{sc}) from the open circuit voltage (V_{oc}) of the cell just prior to the short circuit. A conversion factor of 4.18 was then used to convert joules to calories.

$$\text{Heat} = (\Delta V \int I\,dt)/4.18 \quad \text{where} \quad \Delta V = V_{oc} - V_{sc} \tag{1}$$

The amount of heat used to raise the cell temperature from the initial to the peak value was then calculated as illustrated in equation (2). Values were obtained by multiplying the known heat capacity of the cell by the rise in temperature (K) and by the weight (grams) of the cell. The heat capacity of a Li/BCX DD cell was determined in Contract NAS 9-17821 to be 0.2 cal/gK. The temperature rise (ΔT) was obtained by subtracting the initial cell temperature ($T_{initial}$) from the peak cell temperature (T_{peak}). The average weight of a Li/BCX DD cell is approximately 206 grams.

$$\text{Heat (calories)} = 0.2\ \text{cal/gK}(\Delta T)(206\ \text{g}) \quad \text{where} \quad \Delta T = T_{peak} - T_{initial} \tag{2}$$

The total amount of heat generated was compared to the amount of heat used to raise the cell temperature. These values are shown in Table 6. Variation in total circuit resistance affects the current and therefore affects the rate of discharge. Thus, variable contact resistance as well as other factors affecting the total circuit resistance may account for the observed variation in the calculated heat values. Results indicate that approximately 65 - 96% of the total heat generated is lost by a combination of conductive, convective, and radiant effects, and thus the peak temperature of a cell during short circuit is not an accurate indicator of the amount of heat generated by the cell. These findings suggest that since a majority of the heat generated is lost to the surrounding environment, insulated cells tested under the same short circuit conditions would most likely rupture.

5.2 Charging Tests

Charging tests were conducted on a total of 29 discharged cells and 29 fresh cells at rates of 350 mA (96 hours), 1.0 A (24 hours), and 3.5 A (5 hours). During recharge testing, cell voltage and current were monitored, and the surface temperature of the cell was determined by a thermocouple measurement. Test parameters and results are presented in Charging Test Report 90-013 which appears in Appendix G. Cells that were tested at 350 mA and cells that were tested at 1.0 A (fresh and discharged) did not evidence

any physical changes. Nine of the ten fresh cells that were tested at 3.5 A experienced case rupture, while one cell from this group exhibited a vent through the glass seal and case. Nine of the ten discharged cells that were tested at 3.5 A did not evidence any physical changes. However, one cell from this group (SN 32/D249A) experienced a vent through the glass seal 23 seconds after the start of test. This cell had been discharged at -18°C under a 1.0 ohm load. The open circuit voltage of this cell was lower than any other cell in this test group.

After these tests, the cells were discharged at room temperature under 10 ohm loads. The discharge system currently in use is not equipped with an automatic cut-off unit, and thus cells were discharged below 1.5 volts under 10 ohms. Consequently, the cells were not discharged under 20 ohm loads. Individual and average cell capacities are presented in Table 7 along with calculations of standard deviation. Discharge curves are are shown in Figures 43 - 46.

5.3 Overdischarge Tests

Overdischarge testing was performed on a total of 170 discharged cells over three rates (350 mA, 2.0 A, and 5.0 A) and two temperatures (room temperature and 71°C), with and without protective diodes. Cells from the capacity performance tests were used for testing, and were allowed to stand under open circuit conditions for two weeks prior to the commencement of the overdischarge tests. Cells were first tested with diodes installed to prevent overdischarge. The diodes were then removed and the tests were repeated without the diode protection. Current, voltage, and skin temperature were monitored throughout each test. An additional sequence of tests was performed with no diodes for the three rates and two temperatures as outlined above. Test parameters and results are summarized in Overdischarge Report 90-044 which appears in Appendix H. In the discussion that follows, physical changes are referred to as changes that can be observed by visual inspection such as heat stains, case swelling, or venting. Temperature increases are not classified as physical changes. The temperature of some cells may have increased slightly due to an increase in the temperature of the test area, however, temperature increases of <10°C are considered insignificant. The temperature profile of some cells was shown to increase and then decrease rapidly. These temperature diversions are referred to as temperature spikes and are noted in Overdischarge Report 90-044. In some instances, the temperature was shown to increase beyond the upper limit of the chart recorder (250°C), and thus the peak temperature of the spike was not recorded.

350 mA/Room Temperature:

Cells that were tested at 350 mA for 16 hours at room temperature without diodes and cells that were tested with and then without diodes did not evidence any physical changes or significant temperature increases as a result of the overdischarge condition.

350 mA/71°C:

A group of cells was tested at 350 mA for 16 hours at 71°C without diodes. One cell from this group (SN 43/E249) evidenced a temperature spike. This cell reached 209.0°C at 6.2 hours and evidenced a heat stain on its case. The remaining cells from this group did not evidence any physical changes or significant temperature increases. Cells that were tested at 350 mA for 16 hours with and then without diodes did not evidence any physical changes or significant temperature increases.

2 A/Room Temperature:

Two cells that were tested at 2 A for 16 hours without diodes evidenced heat stains on their cases. One of these cells (SN 1/D249C) evidenced a temperature spike. This cell reached 175.5°C at 6 hours. The average time to peak temperature for this group of cells was 6.0 hours. The average peak temperature was 63.9°C. Cells that were tested with diodes did not evidence any physical changes. The average time to peak temperature was 24.0 minutes. The average peak temperature was 43.3°C. The same cells when tested without diode protection evidenced heat stains on their cases. The average time to peak temperature without diode protection was 6.0 hours. The average peak temperature was 93.3°C.

2 A/71°C:

Cells that were tested at 2 A for 16 hours without diodes evidenced a degree of swelling. A few of the cells showed heat stains on their cases. One cell from this group (SN 24/C249B) evidenced a temperature spike. This cell reached 178.5°C at 12.8 hours. The average time to peak temperature for this group of cells was 5.1 hours. The average peak temperature was 136.3°C. Cells that were tested at 2 A for 16 hours with diodes did not evidence any physical changes. The average time to peak temperature was 40.5 minutes. The average peak temperature was 104.3°C. Several of these cells when tested without diodes evidenced case swelling and/or heat stains. Two cells from this group evidenced temperature spikes. SN 43/A299A reached 100.0°C at 44.0 minutes and SN 11/C249C increased to greater than 250°C at 8.6 hours. Both of these cells evidenced heat stains on their cases. The average time to peak temperature for this group of cells was 5.5 hours. The average peak temperature was 112.5°C.

5 A/Room Temperature:

Four cells that were tested at 5 A for 16 hours without diodes vented through the glass seal. Several cells evidenced heat stains and case swelling. Two cells from this group evidenced temperature spikes. SN 46/E249A and SN 42/B249B increased to greater than 250°C at 2.7 hours and 3.2 hours respectively. The average time to peak temperature for this group was 2.6 hours. The average peak temp- erature was 171.3°C. Cells that were tested at 5 A for 16 hours with diodes did not evidence any physical changes. The average time to peak temperature was 33.0 minutes. The average peak temperature was 52.8°C. Two of these cells when tested without diodes vented. Several of the cells swelled and heat stains were evident. SN 24/A249A evidenced a temperature

spike. This cell reached 181.0°C at 3.6 hours. One cell from this group did not evidence any physical changes. The average time to peak temperature for this group was 1.8 hours. The average peak temperature was 120.6°C.

5 A/71°C:

Several cells that were tested at 5 A for 16 hours without diodes evidenced heat stains, and three cells vented through the glass seal. Case swelling was also evident. One cell from this group (SN 17/C249C) evidenced a temperature spike. This cell increased to greater than 250°C at 6.5 hours. The average time to peak temperature for this group was 2.4 hours. The average peak temperature was 150.8°C. Cells that were tested with diodes did not evidence any physical changes. The average time to peak temperature was 43.5 minutes. The average peak temperature was 52.8 °C. These cells when tested without diodes evidenced heat stains and case swelling. The average time to peak temperature was 1.2 hours. The average peak temperature was 120.6°C.

5.4 High Temperature Exposure Tests

High temperature exposure tests were conducted on ten fresh and ten discharged cells. The cells were exposed to a temperature of 149°C for one hour. There was no evidence of electrolyte leakage in any of the cells. The fresh cells were subsequently discharged at room temperature under 10 ohm loads, and then under 20 ohm loads. Individual cell capacities are presented in Table 8 along with group averages and standard deviations. Cells were discharged below 1.5 volts under 10 ohms, and thus delta capacity values are negligible. Discharge curves are shown in Figures 47 and 48.

5.5 Shock and Vibration Tests

Shock and vibration tests were performed to evaluate cell mechanical environmental tolerance. Test parameters and results are detailed in MGA Research Corporation Shock and Vibration Report which appears in Appendix I. The cells were subsequently discharged under 10 ohm loads at room temperature, and then under 20 ohm loads. Individual and average cell capacities are presented in Table 9 along with calculations of standard deviation. Cells were discharged below 1.5 volts under 10 ohms, and thus delta capacity values are negligible. Discharge curves are shown in Figures 49 and 50.

Table 5: Capacities of Short Circuited DD Cells under a 20 ohm Load

Run Number*	Ah to 3.0 V	Ah to 2.5 V	Ah to 2.0 V	Ah to 1.5 V
6524	17.8	18.4	18.6	18.7
6525	0.6	3.7	5.2	5.4
6526	0.0	6.0	6.8	7.2
6527	1.2	6.0	7.1	7.4
6528	0.0	4.8	5.8	6.1
6529	0.0	4.2	6.3	6.8
6530	0.0	8.0	8.8	9.4
6531	17.2	17.7	17.9	18.2
6532	0.0	4.2	5.0	5.2
6533	19.0	19.8	20.2	20.4
6534	0.0	3.3	3.8	4.1
6535	18.3	19.3	19.6	19.9
6536	0.0	3.0	3.6	3.9
6537	0.0	3.4	3.8	4.0
6538	15.5	15.8	16.1	16.2
6539	12.0	12.6	12.8	13.2
6540	18.1	18.7	19.0	19.4
6541	14.6	15.0	15.2	15.4
6542	0.0	5.8	7.0	7.3
6543	0.0	5.6	6.6	7.2
6544	0.0	11.5	12.4	n.a.
6545	0.0	0.0	1.4	1.8
6546	0.0	6.6	7.0	7.6
6547	0.0	6.4	7.6	8.0
6548	3.0	7.4	8.0	8.7
6549	10.0	12.2	12.8	13.0
6550	1.0	3.2	4.6	4.9
6551	3.2	5.3	5.9	6.4
6552	4.8	5.9	6.4	6.7
6553	6.3	9.0	9.2	9.4
6554	5.8	7.8	8.4	8.8
6555	3.1	4.6	5.2	5.8
6556	1.7	3.0	3.8	4.3
6557	11.1	14.1	14.6	15.0
6558	0.0	5.9	7.1	7.5
6559	17.5	18.4	18.6	18.8
6560	2.5	6.8	7.1	7.4
Average	**6.0**	9.5	**10.3**	**10.6**
SD	**7.0**	**5.7**	**5.4**	**5.4**

* Run number assigned for graphing purposes only -
Refer to discharge curves for cell serial number and date code

Table 6: Heat Generated by DD Cells during Short Circuit Tests

Test Temperature (°C)	Discharge Rate (mΩ)	SN (Date Code)	Heat Generated by Cell (kilocalories)	Temperature Δ Cell Temperature (kilocalories)*
24	50	2 (D249A)	17.6	3.8
29		38 (E249B)	15.1	2.9
27		46 (A299B)	15.0	1.6
25	100	3 (C249B)	15.1	3.0
27		1 (D249B)	15.1	3.7
25		23 (B249C)	22.9	3.4
19	500	39 (A249B)	47.7	1.9
23		32 C(C249C)	38.0	1.7
17		35 (D249C)	42.2	1.5
71	50	Not Available		
71	100	17 (E249A)	34.9	5.8
71		28 (B249B)	15.5	5.4
71		42 (D249B)	29.4	4.1
71	500	29 (D249C)	11.3	0.7
71		30 (D249B)	30.5	1.3
71		35 (E249B)	12.9	0.7

* Amount of heat used to raise cell temperature from initial to peak value used to illustrate the substantial amount of heat which is lost to the surrounding environment

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.1 OHM AT RT

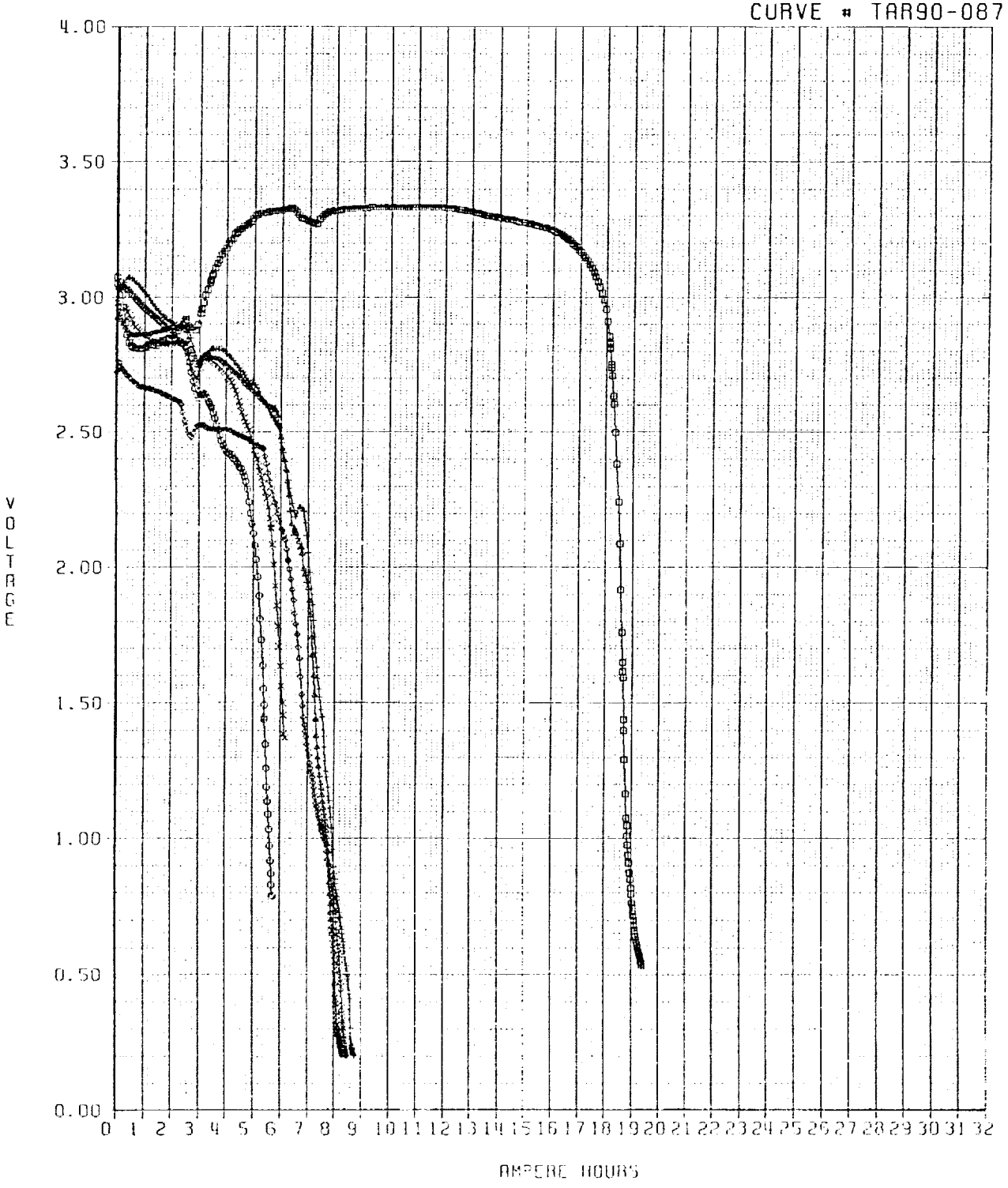
Figure 35

S/N 6524 □ A299A - 48
S/N 6525 ⊙ A249B - 47
S/N 6526 △ E249B - 3
S/N 6527 + E249A - 32
S/N 6528 × D249B - 1
S/N 6529 ◇ C249B - 3
DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 21FEB90
CURVE # TAR90-087



GPLOT(REV. 3.1)

DAT 050 TUE, FEB 27 1990 09:32:01 AM

Figure 36

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.1 OHM AT RT

S/N 6530 □ B249B-43 S/N 6531 ○ B249C-23

DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT D. STEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 21FEB90
CURVE # TAR90-087A

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.5 OHM AT 71°C

Figure 37

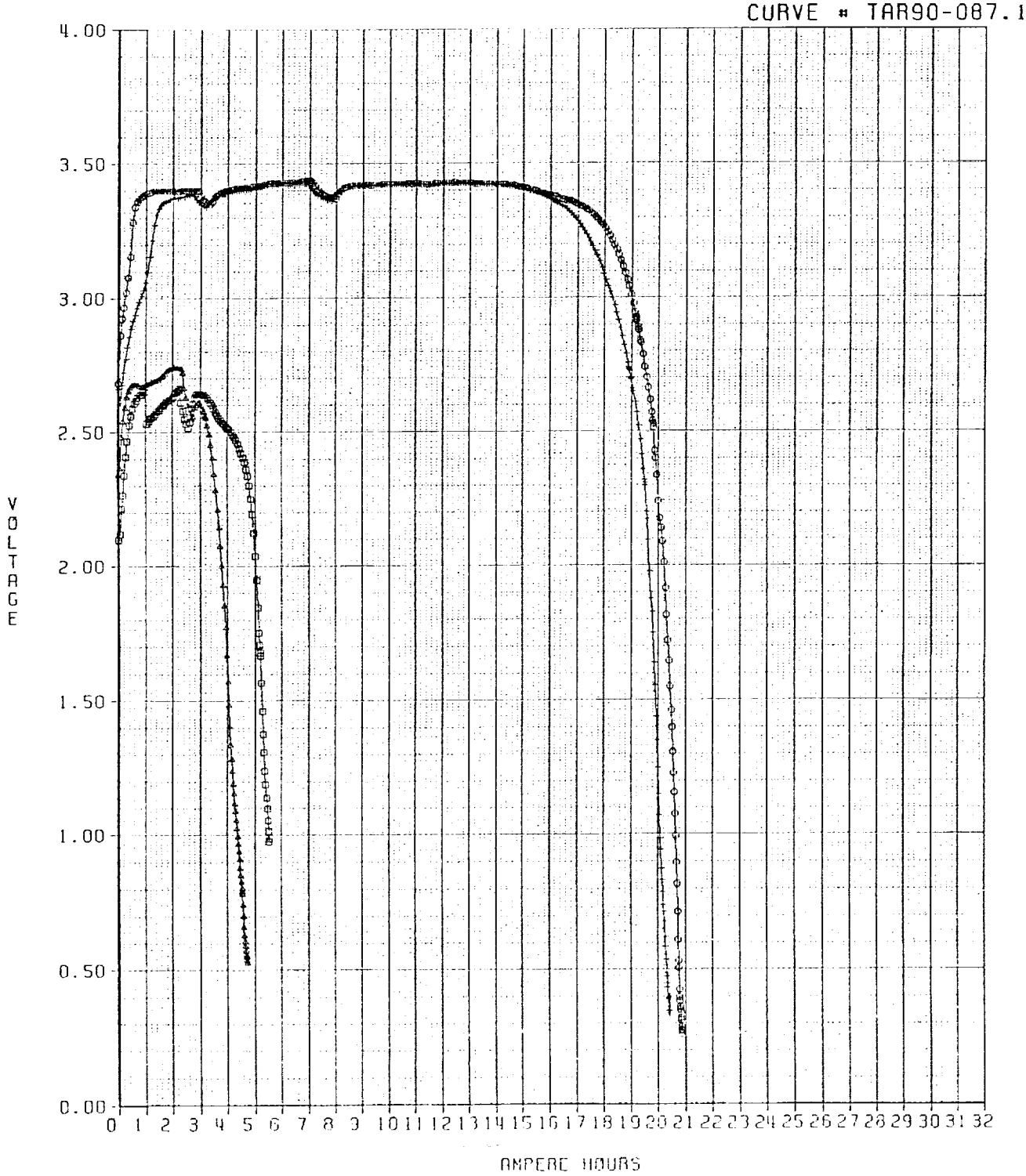
S/N 6532 □ D249B - 30 S/N 6533 ⊙ B249C - 1
S/N 6534 △ C249B - 29 S/N 6535 + A249A - 43

DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 21FEB90
CURVE # TAR90-087.1



GPLOT(REV. 3.1)

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OF POOR QUALITY

DAY 058 TUE, FEB 27 1990 10:45:11 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.5 OHM AT 71°C

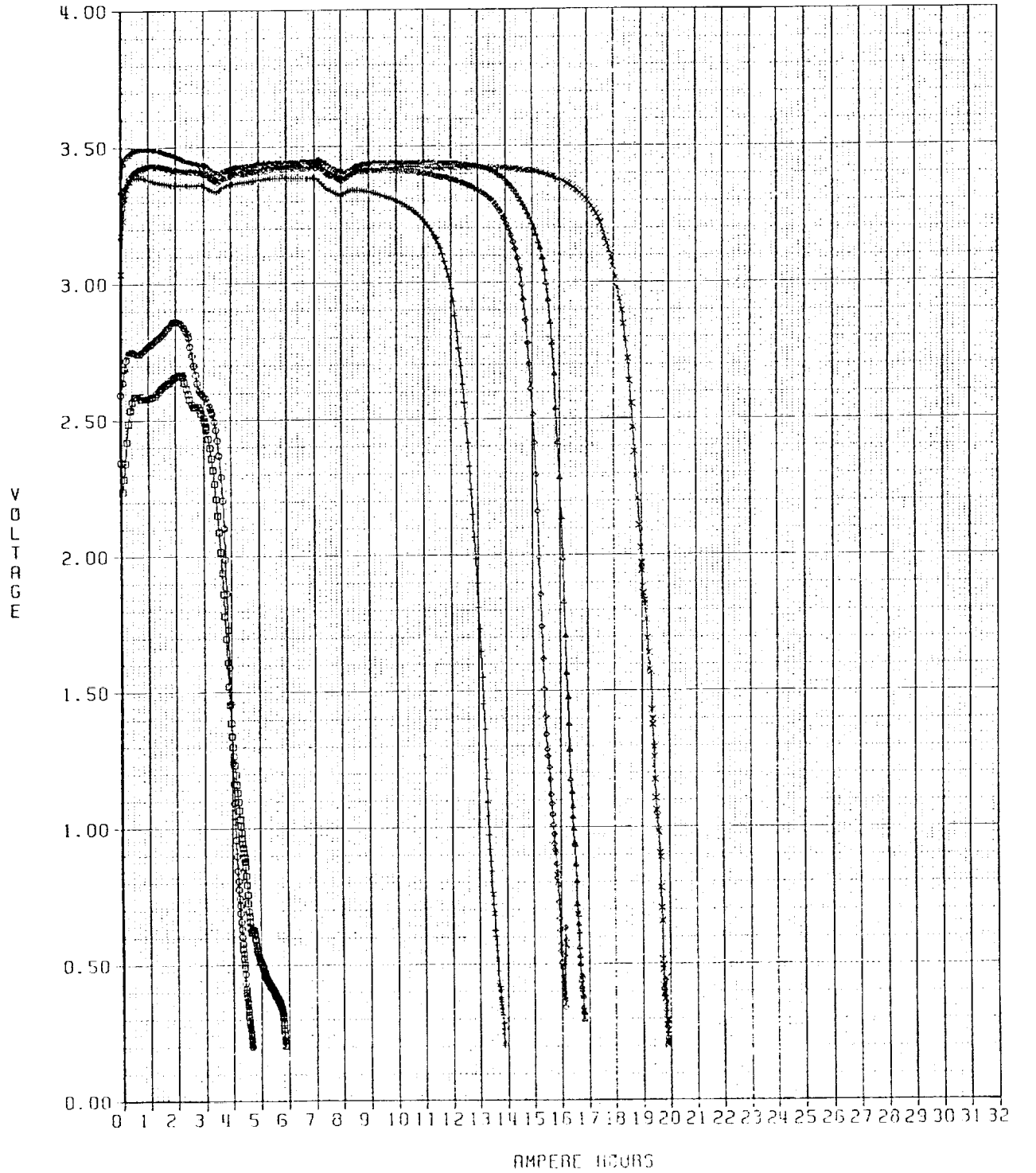
Figure 38

S/N 6536 □ B249A -34 S/N 6537 ⊙ D249A -28
S/N 6538 △ E249B -35 S/N 6539 + A299B -21
S/N 6540 × A299A -26 S/N 6541 ◇ D249C -29
DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 21FEB90
CURVE # TAR90-087.2



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GPLOT(REV. 3.1)

DAY 058 TUE, FEB 27 1990 09:23:44 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.5 OHM AT RT

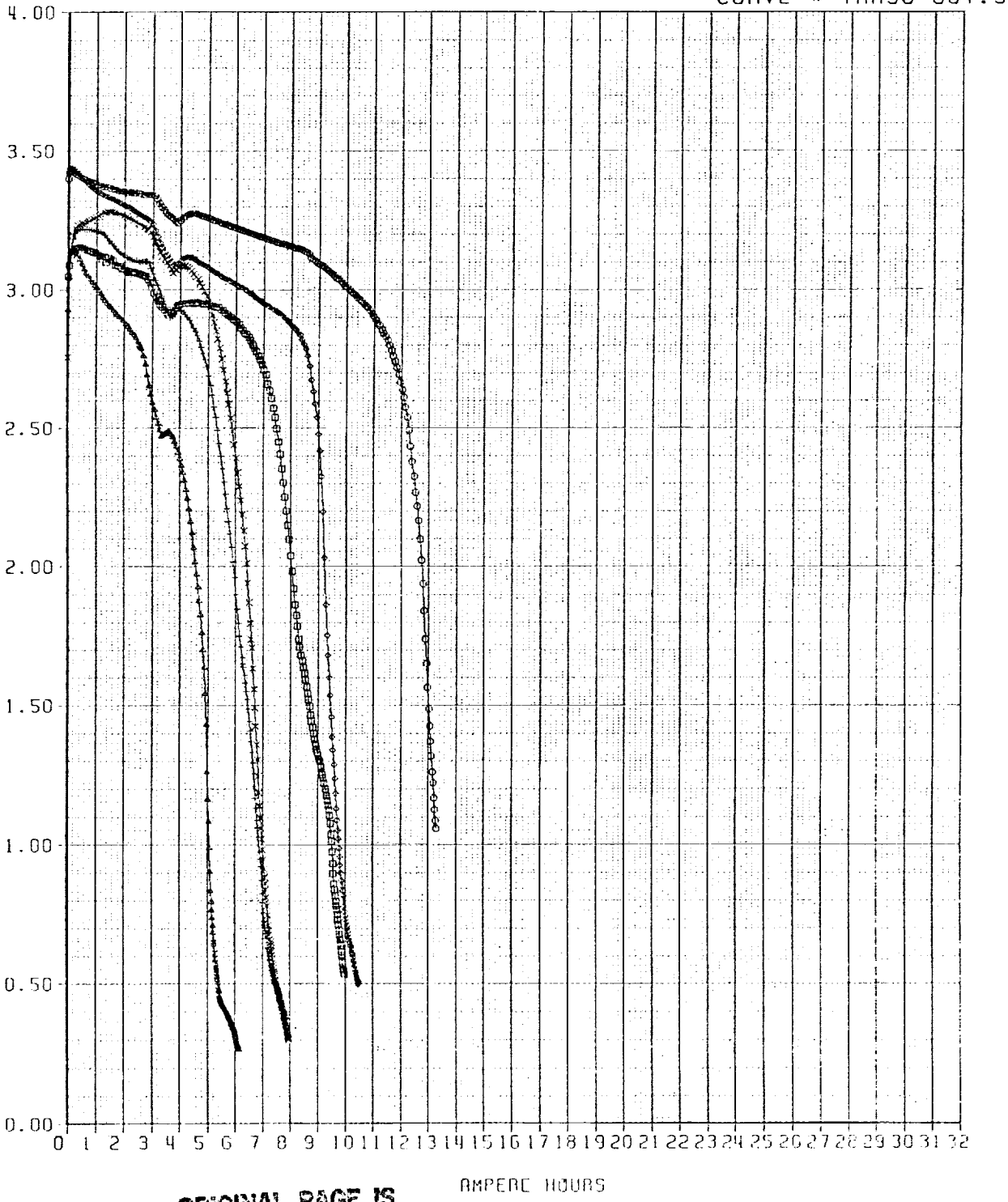
Figure 39

S/N 6548 □ B249A - 9
S/N 6549 ○ A299B - 35
S/N 6550 △ E249A - 25
S/N 6551 + D249C - 35
S/N 6552 × D249A - 35
S/N 6553 ◇ A299A - 9
DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 27FEB90
CURVE # TAR90-087.3



BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.5 OHM AT RT

Figure 40

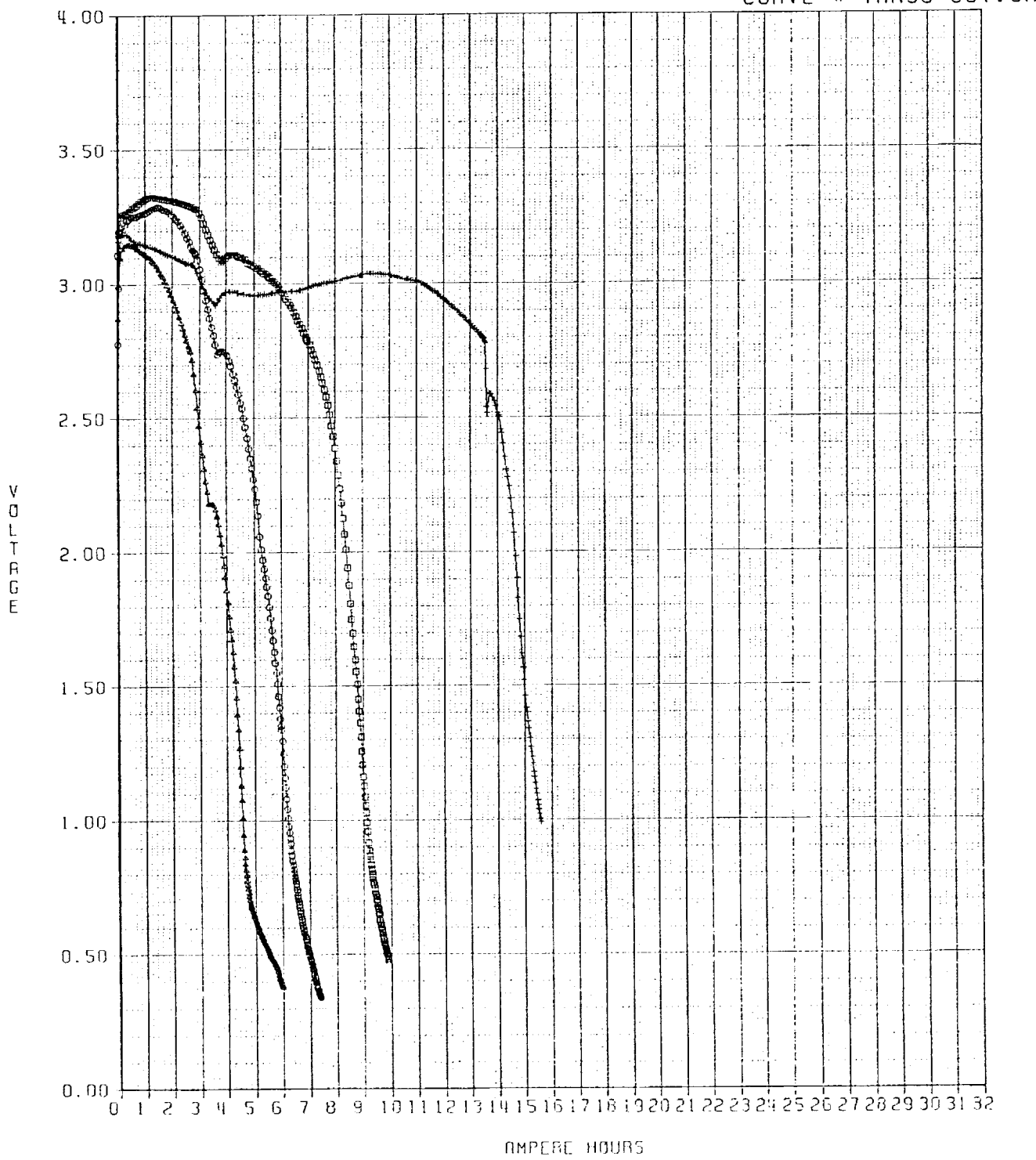
S/N 6554 □ C249C - 32 S/N 6555 ⊙ D249B - 2
S/N 6556 △ A249B - 39 S/N 6557 + B249B - 20

DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL G. WEBSTER S. EBEL R. SAMIT
D. STEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 22FEB90
CURVE # TAR90-087.3A



GPLOT(REV. 3.1)

041 058 TUE, FEB 27 1990 10:36:50 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.05 OHM AT RT

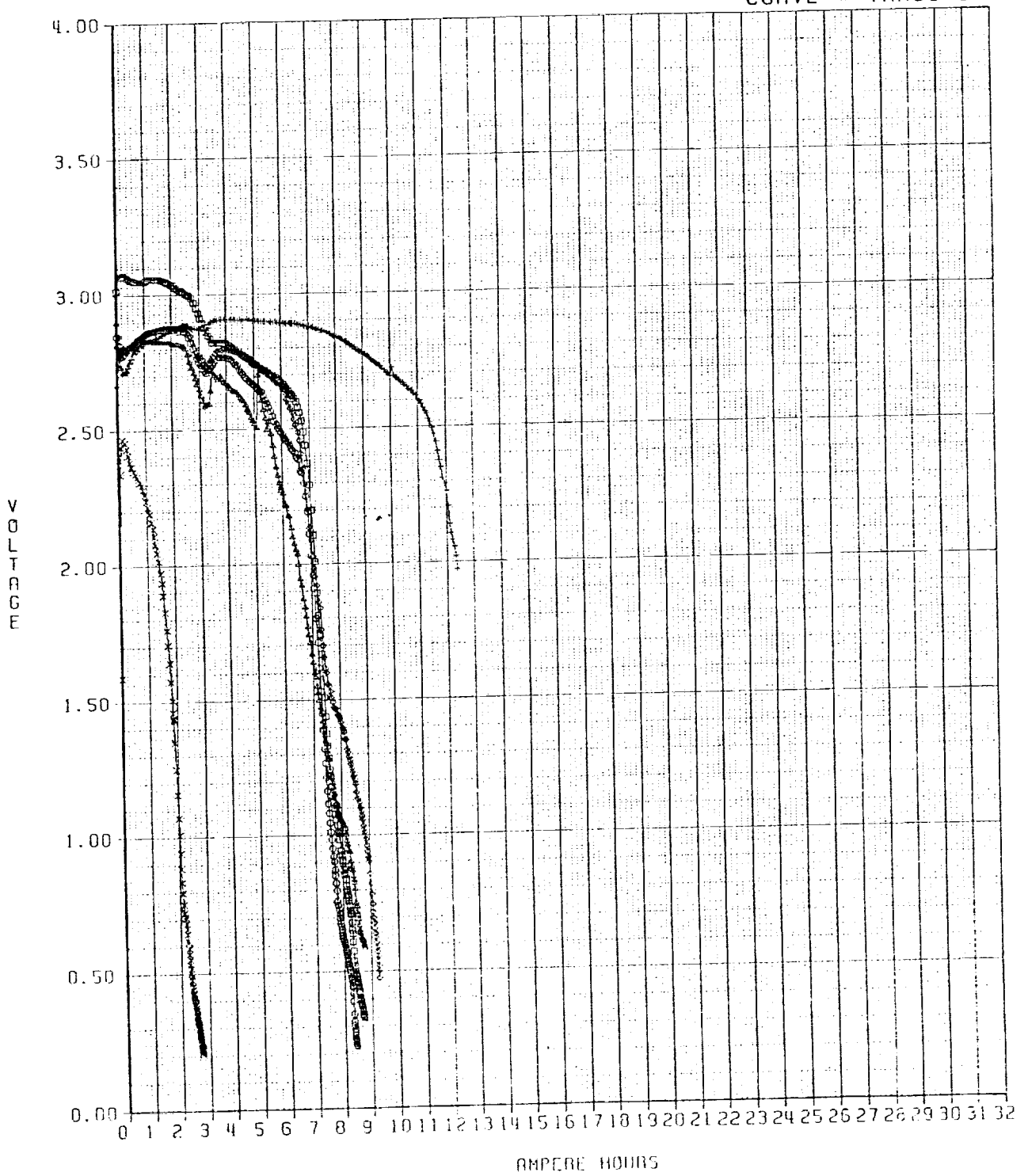
Figure 41

S/N 6560 □ C249B – 6
S/N 6543 △ B249C – 33
S/N 6545 × A299A – 14
S/N 6542 ⊙ D249B – 47
S/N 6544 + D249C – 26
S/N 6546 ◇ B249A – 47
DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. ESEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 22FEB90
CURVE # TAR90-087.4



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DAY 058 TUE, FEB 27 1990 11:36:55 AM

BCX 1490D - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS SHORT CIRCUIT 0.05 OHM AT RT

Figure 42

S/N 6547 □ A299B – 46 S/N 6558 ⊙ D249A – 2
S/N 6559 △ E249B – 38

DISCHARGED AT ROOM TEMPERATURE UNDER A 20 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 22FEB90
CURVE # TAR90-087.4A

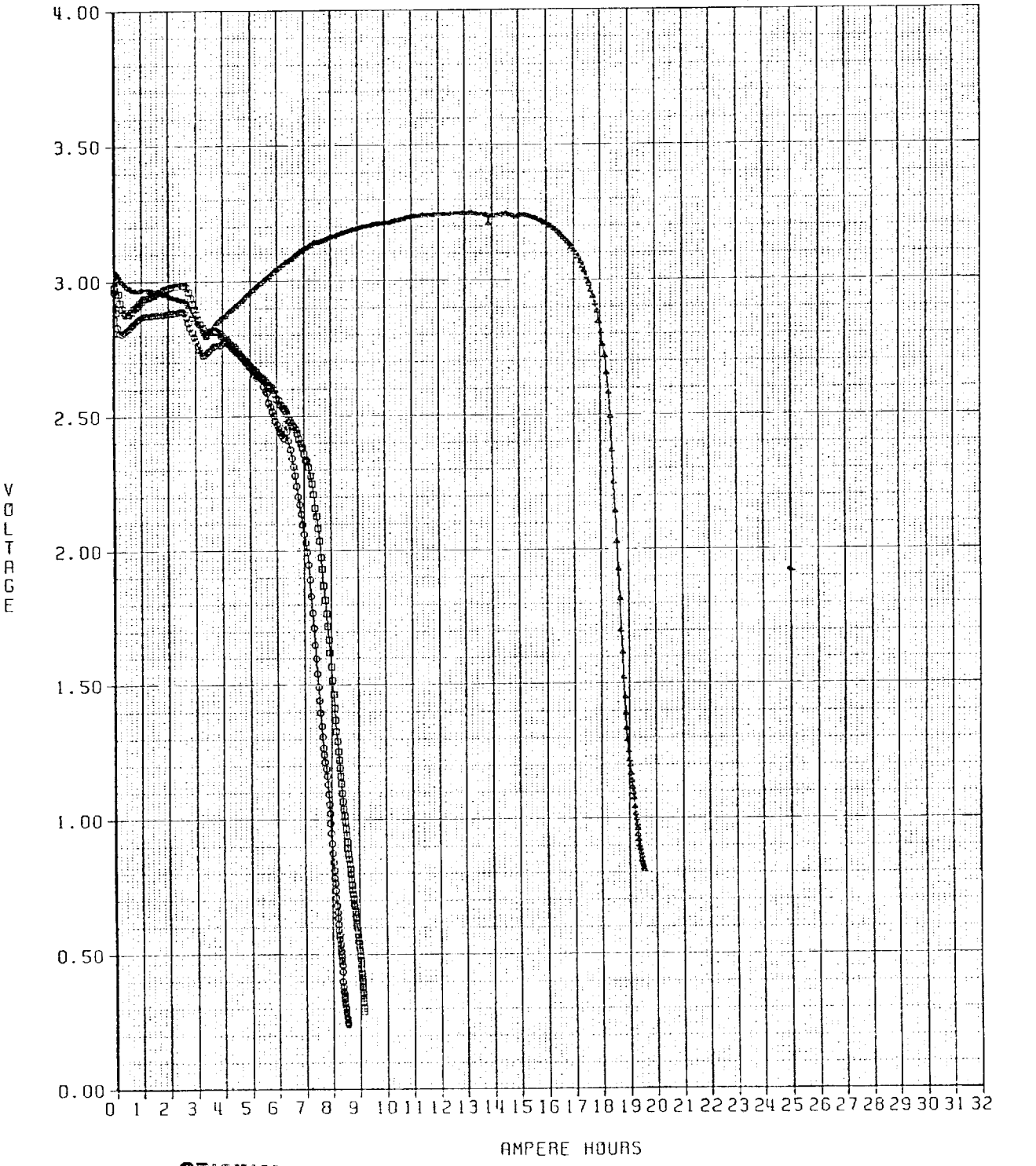


Table 7: Capacities of Recharged DD Cells under a 10 ohm Load

Run Number*	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
19855	20.2	21.0	21.5	22.0	0.0
19856	24.2	24.6	24.9	25.1	0.0
19857	17.3	17.7	18.0	18.2	0.0
19858	0.0	0.1	1.9	4.0	0.0
19859	25.2	25.4	25.5	25.6	0.0
19860	12.6	14.3	15.0	15.4	0.0
19861	14.8	15.4	15.7	15.8	0.0
19862	0.0	0.0	0.0	0.0	0.0
19863	23.8	24.4	24.6	24.7	0.0
19864	24.6	25.1	25.2	25.4	0.0
19865	16.4	17.5	18.2	18.6	0.0
19866	25.0	25.4	25.5	25.6	0.0
19867	24.7	25.1	25.3	25.4	0.0
19868	24.9	25.3	25.6	25.7	0.0
19869	25.1	25.5	25.7	25.8	0.0
19870	24.9	25.4	25.6	25.8	0.0
19871	25.1	25.6	25.8	26.0	0.0
19872	0.0	5.5	6.8	7.2	0.0
19873	23.8	24.3	24.6	24.7	0.0
19874	25.0	25.4	25.6	25.7	0.0
Average	**18.9**	**19.65**	**20.1**	**20.3**	0.0
SD	**9.0**	**8.5**	**8.3**	**8.0**	

* Run number assigned for graphing purposes only -
Refer to discharge curves for cell serial number and date code

BCX 1490D - 382085-XA
NASA LOT PERFORMANCE
FRESH CELLS RECHARGE AT 350 MA FOR 96 HRS.

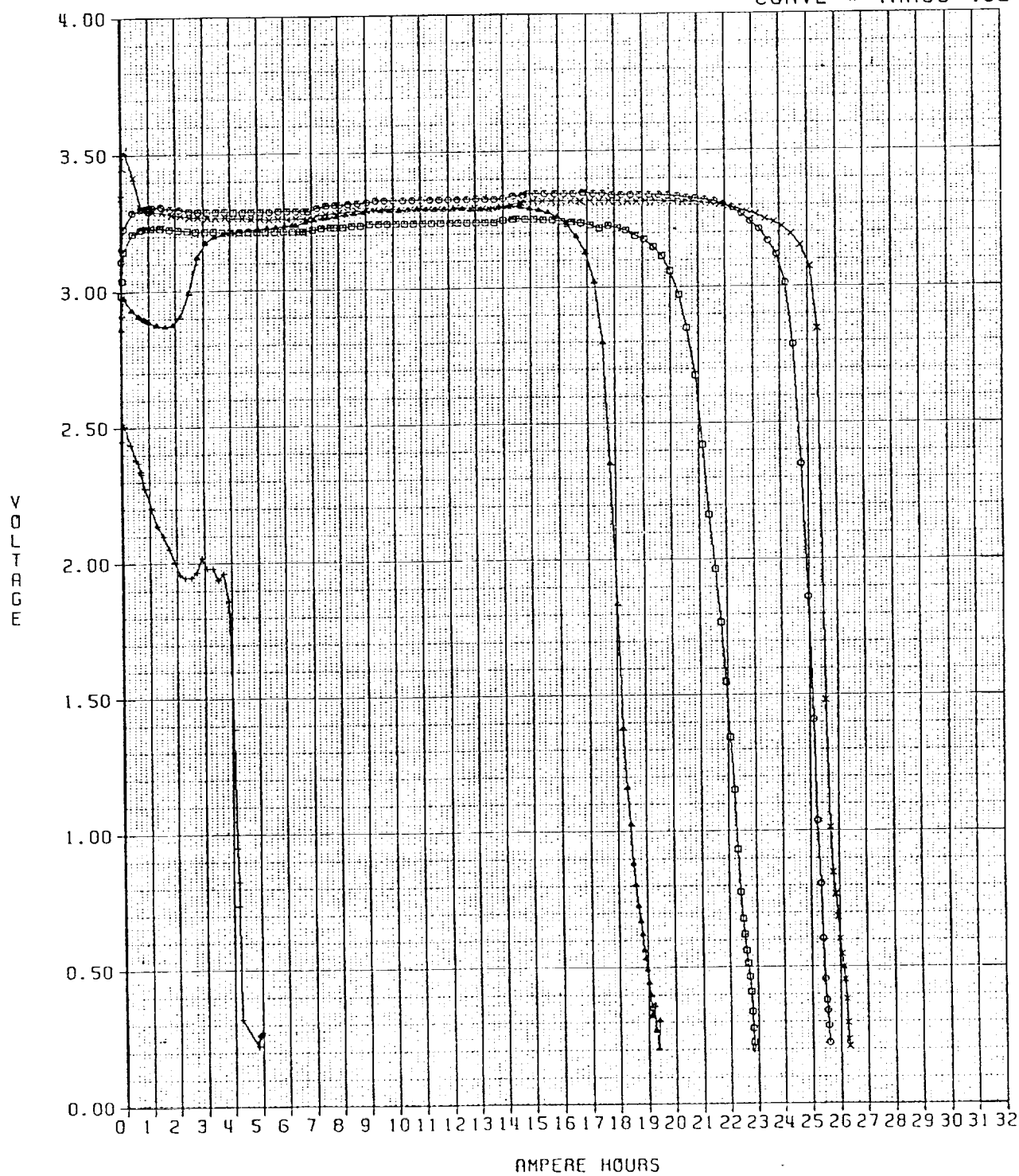
Figure 43

S/N 19855 □ C249B -46
S/N 19857 △ A249A -22
S/N 19859 × D249B -29
S/N 19856 ⊙ B249A -10
S/N 19858 + C249C - 8
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KREHL, B. WEBSTER, S. EBEL, R. SAMIT, D. SIEMINSKI, R. STINEBRING, R. NEUMANN, S. MEYER

WG

ON TEST 20DEC89
CURVE # TAR89-482



BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS RECHARGE AT 350 MA FOR 96 HRS.

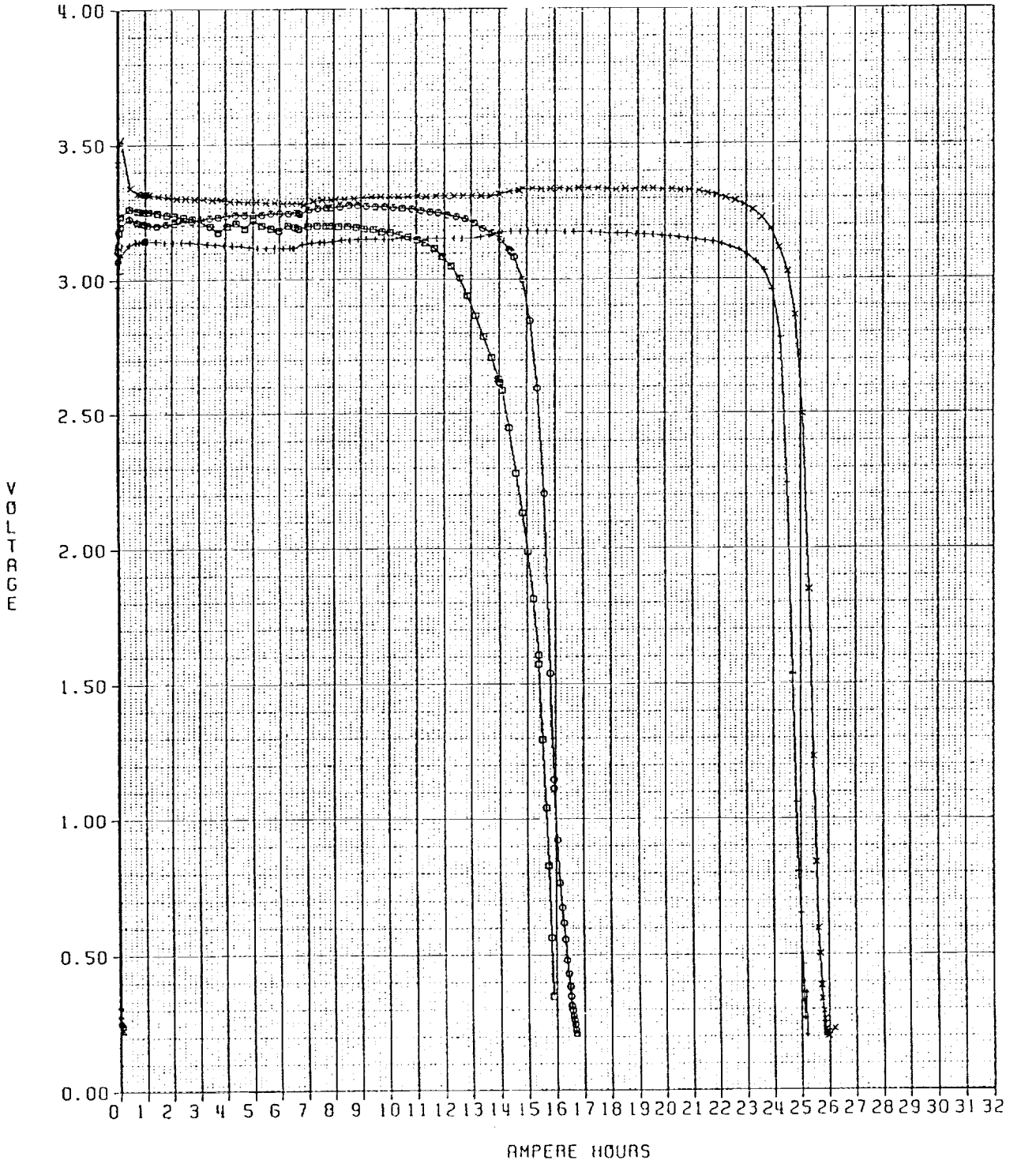
Figure 44

S/N 19860 □ A299A - 41
S/N 19862 △ A299B - 24
S/N 19864 × 0249A - 6
S/N 19861 ○ B249C - 12
S/N 19863 + 0249A - 46
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION:
P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 20DEC89
CURVE # TAR89-482.1



GPLOT(REV. 3.1)

DAY 362 THU, DEC 28 1989 08:40:37 AM

BCX 149DD - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS RECHARGE AT 1 AMP FOR 24HRS.

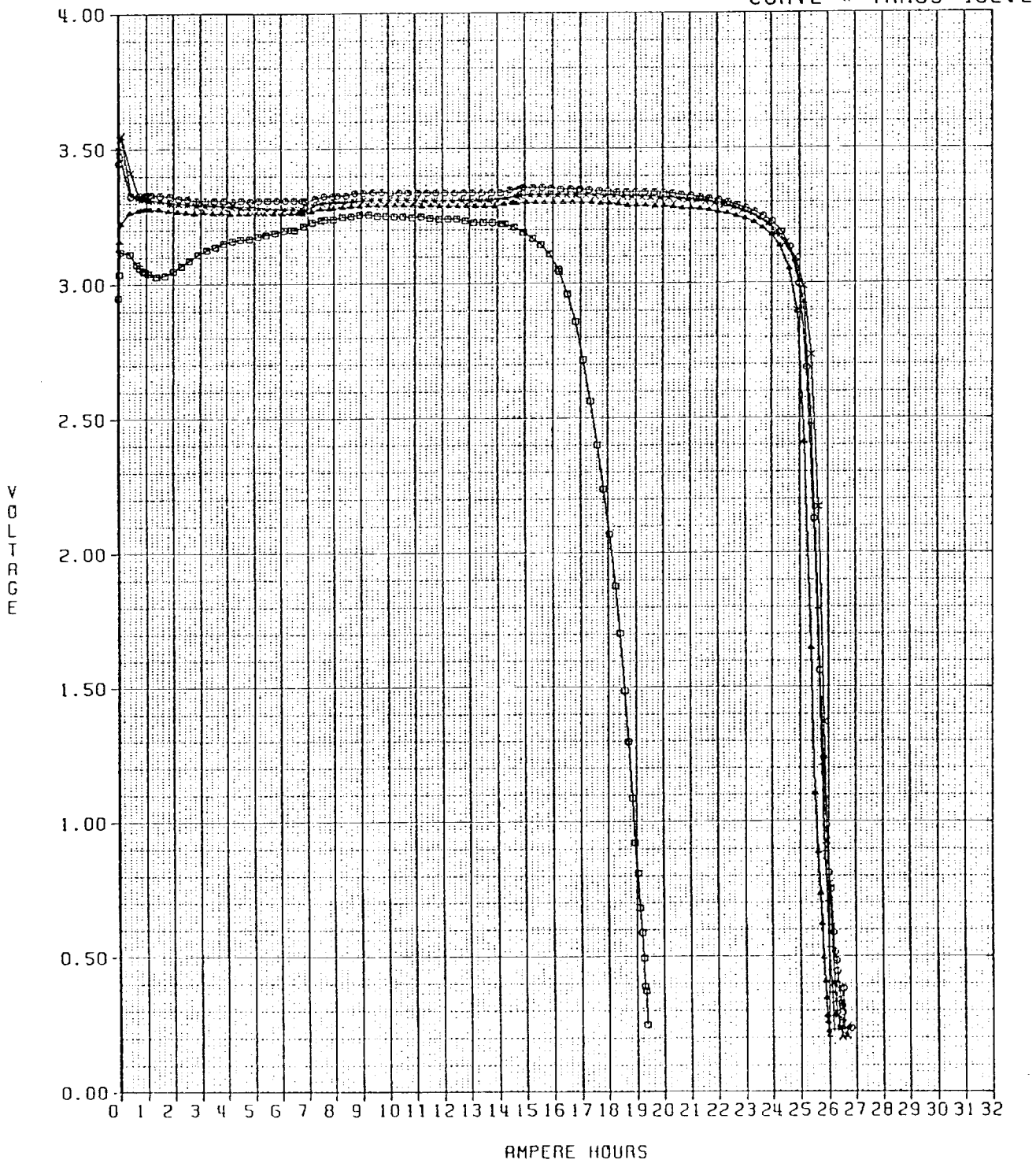
Figure 45

S/N 19865 □ A299A - 4
S/N 19866 ○ B249A - 23
S/N 19867 △ B249C - 5
S/N 19868 + E249B - 42
S/N 19869 × E249A - 35
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION:
P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 20DEC89
CURVE # TAR89-482.2



GPLOT(REV. 9.1)

DAY 362 THU. DEC 28 1989 08:43:41 AM

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
FRESH CELLS RECHARGE AT 1 AMP FOR 24HRS.

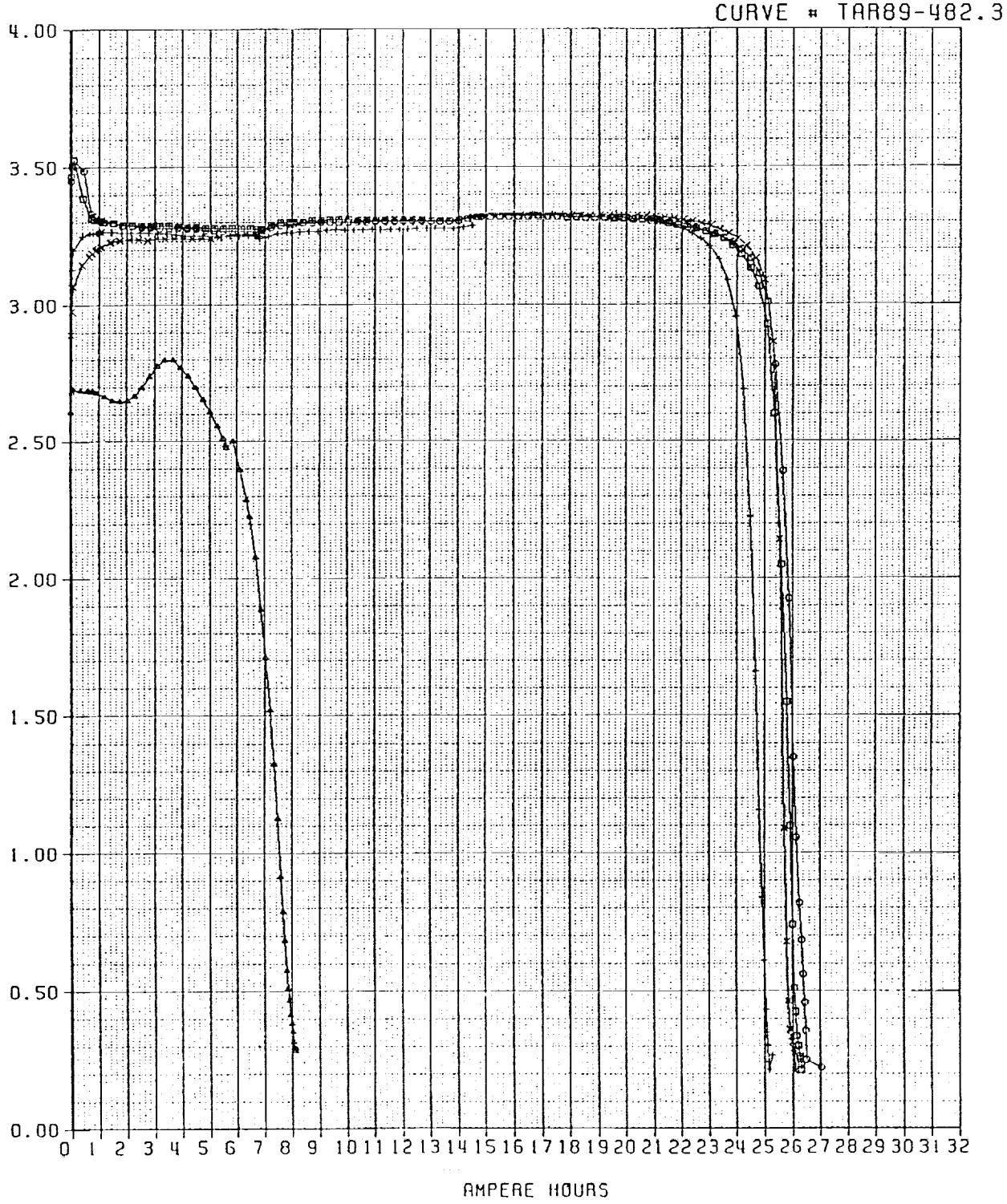
Figure 46

S/N 19870 □ D249C - 30 S/N 19871 ○ D249B - 25
S/N 19872 △ A249B - 38 S/N 19873 + D249A - 8
S/N 19874 × A299B - 40
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KREHL G. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 20DEC89
CURVE # TAR89-482.3



GPLOT(REV. 3.1)

DAY 362 THU. DEC 28 1989 08:46:50 AM

Table 8: Capacities of High Temperature Exposed DD Cells under a 10 ohm load

Run Number*	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
18435	28.4	28.6	28.8	29.0	0.0
18436	27.6	28.0	28.5	29.0	0.0
18437	27.7	27.8	28.1	28.6	0.0
18438	27.7	27.9	28.2	28.5	0.0
18439	27.2	27.5	27.7	28.0	0.0
18440	27.6	28.0	28.4	28.6	0.0
18441	27.8	28.2	28.4	28.6	0.0
18442	27.4	27.9	28.2	28.4	0.0
18443	28.8	29.2	29.5	29.8	0.0
18444	28.2	28.4	28.5	28.6	0.0
Average	**27.8**	**28.2**	**28.4**	**28.7**	0.0
SD	**0.5**	**0.5**	**0.5**	**0.5**	

* Run number assigned for graphing purposes only -
Refer to discharge curves for cell serial number and date code

FIGURE 47

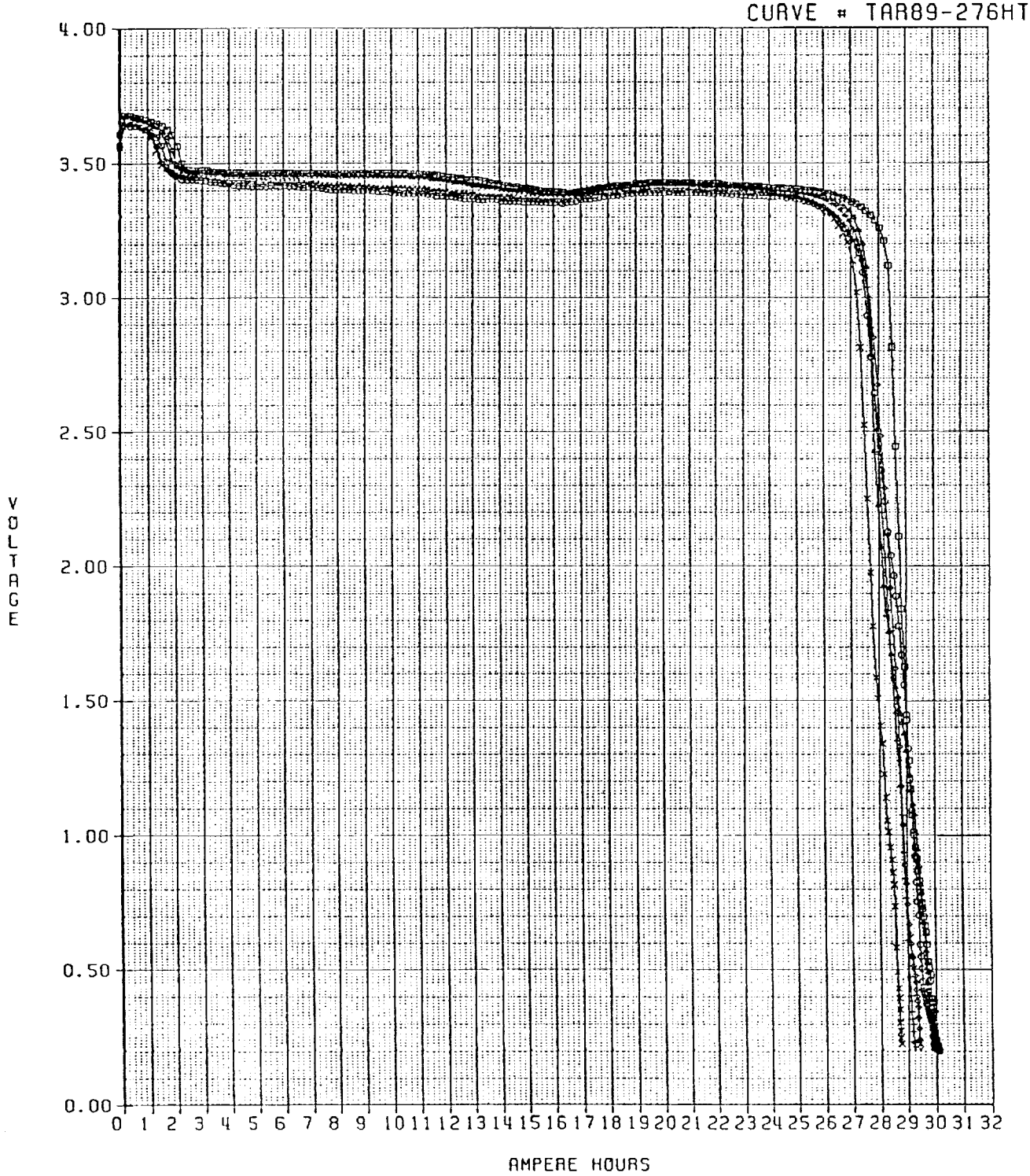
BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
HIGH TEMPERATURE EXPOSURE

S/N 18435 □ A249A - 17 S/N 18436 ○ B249A - 29
S/N 18437 △ B249C - 30 S/N 18438 + C249C - 20
S/N 18439 × D249A - 15 S/N 18440 ◇ D249B - 35
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD - 20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 13SEPT89
CURVE # TAR89-276HT



GPLOT(REV. 3.1) DAY 284 WED, OCT 11 1989 12:03:29 PM

FIGURE 48

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
HIGH TEMPERATURE EXPOSURE

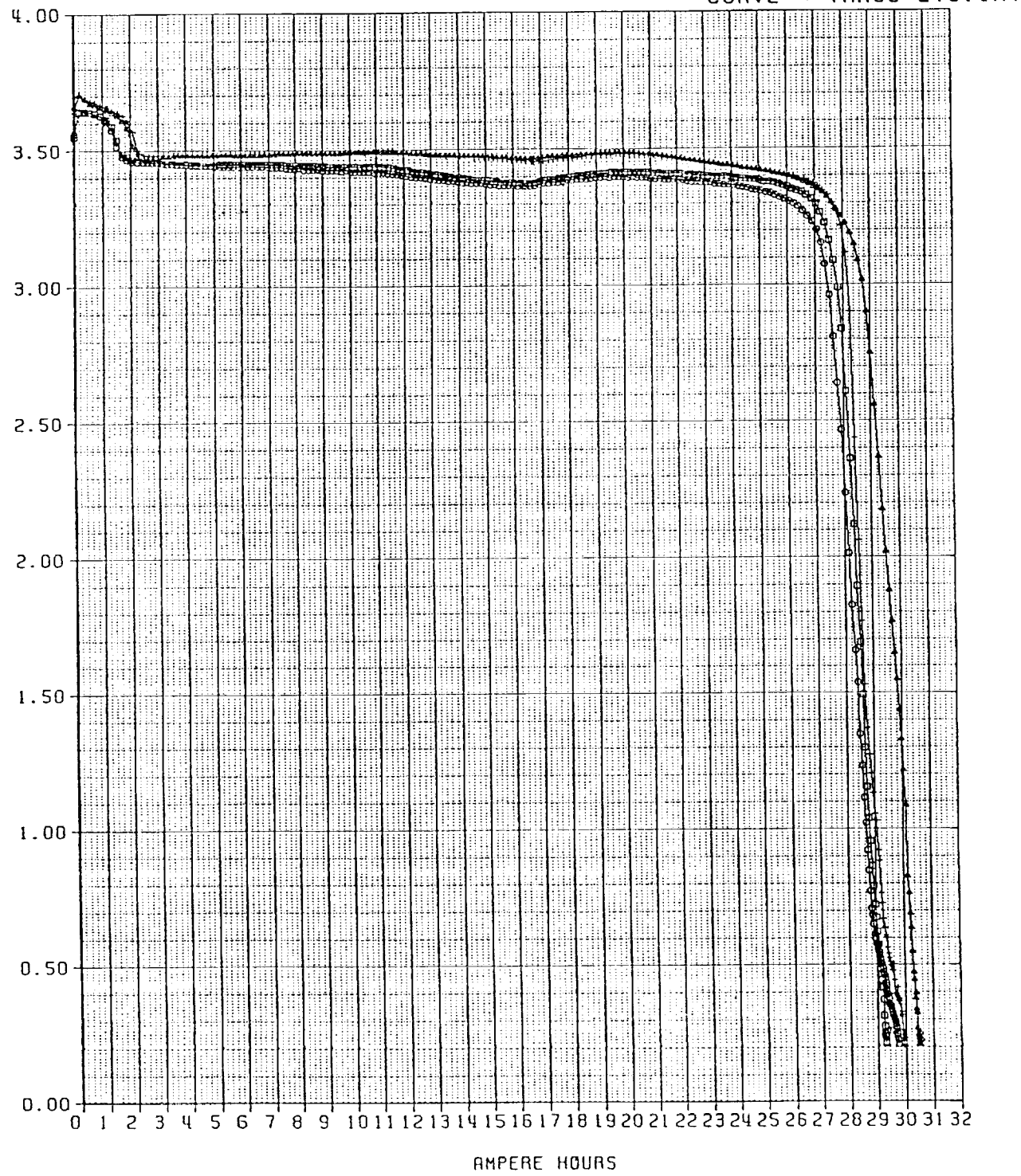
S/N 18441 □ D249C – 25
S/N 18442 ⊙ E249A – 9
S/N 18443 △ A299A – 31
S/N 18444 + A299B – 38

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD - 20 OHM DELTA DISCHARGE

STRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 13SEPT89
CURVE # TAR89-276.1HT



GPLOT(REV. 3.1)

DAY 284 WED. OCT 11 1989 12:00:52 PM

Table 9: Capacities of Shocked and Vibrated DD Cells under a 10 ohm Load

Run Number*	Ah to 3.0V	Ah to 2.5V	Ah to 2.0V	Ah to 1.5V	ΔAh to 1.5V
18919	28.8	29.0	29.2	29.4	0.0
18920	26.8	27.2	27.4	27.6	0.0
18921	27.4	27.7	27.9	28.0	0.0
18922	27.6	27.9	28.1	28.2	0.0
18923	26.5	26.8	26.9	27.0	0.0
18924	26.3	26.6	26.9	27.2	0.0
18925	26.2	26.6	26.9	27.1	0.0
18926	26.6	27.0	27.2	27.5	0.0
18927	28.2	28.6	28.7	28.8	0.0
18928	28.2	28.6	28.7	28.8	0.0
Average	**27.3**	**27.6**	**27.8**	**28.0**	0.0
SD	**0.9**	**0.9**	**0.9**	**0.8**	

* Run number assigned for graphing purposes only -
Refer to discharge curves for cell serial number and date code

BCX 14900 - 382085-XA
NASA LOT PERFORMANCE
SHOCK AND VIBRATION TESTING

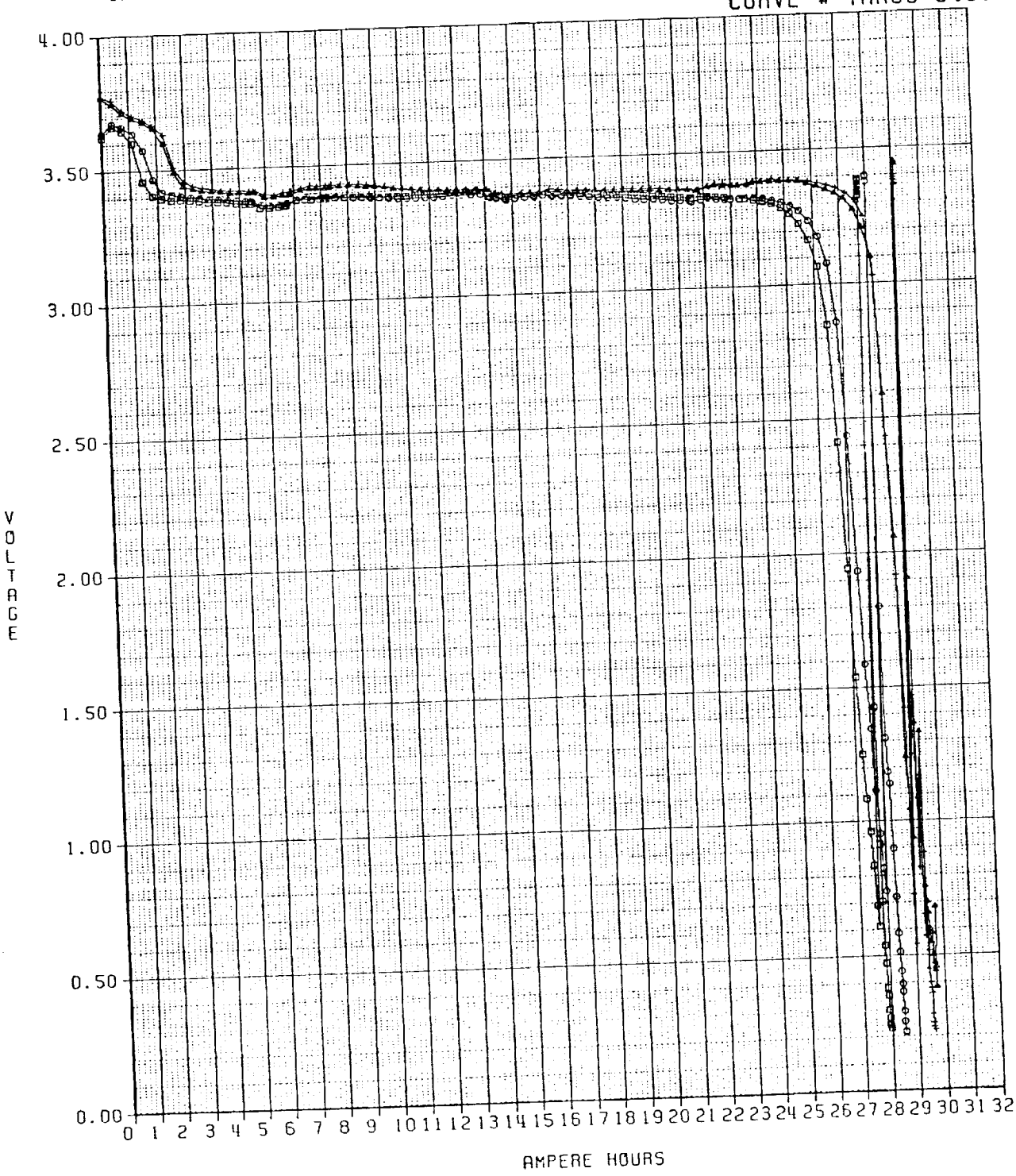
Figure 49

S/N 18925 □ D249C - 34
S/N 18927 △ A299A - 18
S/N 18926 ⊙ E249B - 30
S/N 18928 + A299B - 42

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD- 20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KAEHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

ON TEST 020CT89
CURVE # TAR89-340.1



DAY 284 WED. OCT 11 1989 10:12:46 AM

GPLOT (REV. 9.1)

BCX 14900 - 3B2085-XA
NASA LOT PERFORMANCE
SHOCK AND VIBRATION TESTING

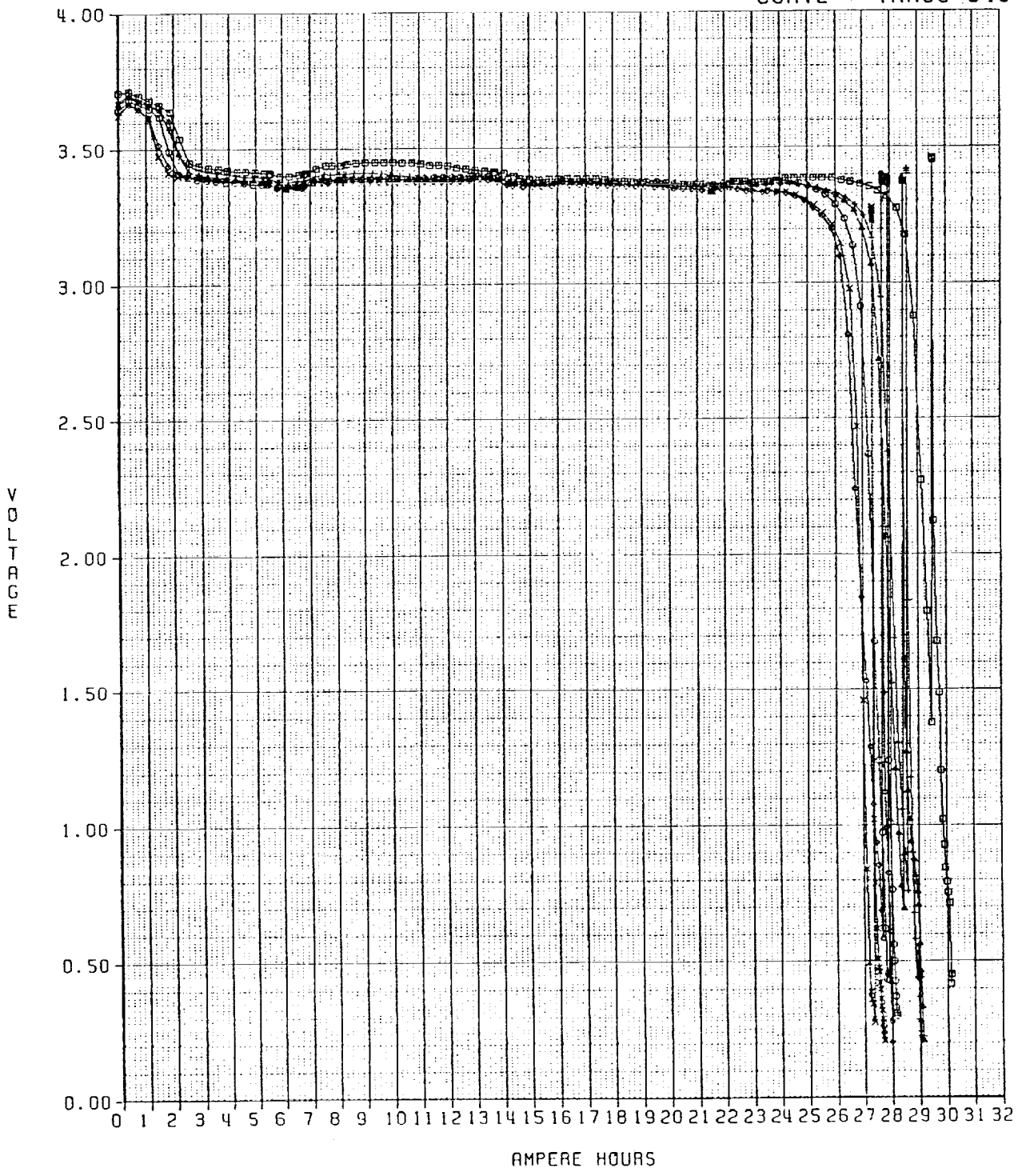
Figure 50

S/N 18919 □ A249B - 44
S/N 18920 ⏀ B249B - 35
S/N 18921 △ B249C - 26
S/N 18922 + C249B - 14
S/N 18923 × D249A - 21
S/N 18924 ◇ D249B - 48
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD - 20 OHM DELTA DISCHARGE

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN S. MEYER

WG

ON TEST 020CT89
CURVE # TAR89-340



6. Summary

6.1 Manufacture Li/BCX 149 DD Cells

A total of 672 Li/BCX DD cells were constructed in four separate lots according to the provisions of Electrochem Industries Quality Plan 17096. The cells were constructed according to the design proved to withstand the 149°C exposure under contract NAS 9-17821. This design uses a shortened cell stack and a thicker header compared to the standard design employed by Electrochem Industries in their commercial product.

6.2 Acceptance and Lot Certification Testing

Acceptance testing was performed according to NASA JSC Document EP5-83-025, Revision B. These requirements involved open circuit and load voltage check, visual examination, physical measurements of cell size and weight, and high temperature exposure. A total of 657 cells successfully passed all acceptance test requirements. Lot sample tests for cell capacity, and thermal and electrical abuse were then performed on a total of 129 cells. These tests included 149°C exposure, capacity discharge, fuse check, high temperature exposure, high rate discharge, short circuit, vibration, and overdischarge. Following the completion of acceptance and lot certification testing, a quantity of 200 cells was delivered to Johnson Space Center for life test evaluation.

6.3 Performance Testing

Electrical performance testing was conducted on a total of 170 cells over four temperatures (-40, -18, RT, or 71°C), and at four discharge rates (1.0, 1.5, 5.0, or 10.0 ohms). After the cells were discharged to below 1.5 volts under the above conditions, a delta discharge was performed on the cells at room temperature under a 20 ohm load. One cell that was discharged under 5 ohms at -18°C was destructively analyzed due to inferior performance (3.6 Ah to 1.5 volts). Destructive analysis results indicate that the cell may have been inadvertently short circuited during testing. The average delivered capacity to 1.5 volts for cells discharged under 1.0 ohm at -40°C, -18°C, room temperature, and 71°C was 9.9, 13.1, 23.7, and 18.9 Ah respectively. The average delivered capacity to 1.5 volts for cells discharged under 1.5 ohms at -40°C, -18°C, room temperature, and 71°C was 8.8, 13.9, 26.8, and 23.1 Ah respectively. The average delivered capacity to 1.5 volts for cells discharged under 5.0 ohms at -40°C, -18°C, room temperature, and 71°C was 13.3, 19.2, 29.4, and 26.0 Ah respectively. The average delivered capacity to 1.5 volts for cells discharged under 10.0 ohms at -40°C, -18°C, room temperature, and 71°C was 15.3, 23.7, 29.3, and 25.8 Ah respectively. Cells that were discharged under 5.0 or 10.0 ohms delivered greater average capacity than cells that were discharged under 1.0 or 1.5 ohms. As temperature was increased from -40°C to room temperature, the average delivered capacity of the cells increased. As temperature was increased from room temperature to 71°C, average performance was shown to decrease. Temperature of two cells per group was monitored throughout discharge. The rise in cell temperature was shown to increase as the rate of discharge was increased (refer to Appendix C).

6.4 Abuse Testing

6.4.1 Short Circuit Tests

Short circuit tests were conducted on a total of 51 uninsulated cells under resistances of 0.5, 0.1, or 0.05 ohms: with initial cell temperatures of room temperature or 71°C. Cell voltage, current, and temperature were monitored and recorded. Cell temperature was monitored utilizing a thermocouple taped to the side of the cell.

The total heat generated during the short circuit condition was calculated from the voltage, and current measurements. Three cells that were tested at 0.05 ohms at room temperature generated an average of 15.9 Kcal. Data are not available for cells tested at 0.05 ohms at a temperature of 71°C. Three cells that were tested at 0.1 ohms at room temperature generated an average of 17.7 Kcal, and three cells that were tested at 71°C generated an average of 26.6 Kcal. Three cells that were tested at 0.5 ohms at room temperature generated an average of 42.6 Kcal, while three cells that were tested at 71°C generated an average of 18.2 Kcal. The amount of heat used to raise the cell temperature from the initial to the peak value was also calculated, and compared to the amount of heat generated by the cell. Results indicate that approximately 65 - 96% of the total heat generated is lost by a combination of conductive, convective, and radiant effects, and thus the peak temperature of a cell is not an accurate indicator of the amount of heat generated. Cells that were not damaged or destroyed were discharged at room temperature under 20 ohm loads following short circuit testing. The cells delivered an average of 9.6 Ah to 1.5 volts.

6.4.2 Charging Tests

Charging tests were conducted on a total of 29 discharged cells and 29 fresh cells at rates of 350 mA, 1.0 A, and 3.5 A. Cell voltage, current, and temperature were monitored and recorded. The cells were discharged at room temperature under 10 ohm loads following charging tests, and delivered an average of 20.3 Ah to 1.5 volts. Fresh and discharged cells that were tested at 350 mA or 1.0 A did not evidence any physical changes. All of the fresh cells that were tested at 3.5 A experienced case rupture while nine out of ten discharged cells that were tested at 3.5 A did not evidence any physical changes.

6.4.3 Overdischarge Tests

Overdischarge tests were performed on a total of 170 discharged cells over three rates (350 mA, 2.0 A, and 5.0 A) and two temperatures (room temperature and 71°C), with and without protective diodes. Current, voltage, and cell temperature were monitored throughout testing. Cells that were tested with protective diodes did not evidence any physical changes. One cell that was tested at 350 mA (71°C) without diode protection evidenced a temperature spike and heat stain on its case. The remainder of the cells that were tested at 350 mA without diodes did not evidence any physical changes or significant temperature increases. Two cells out of twenty that were tested at 2 A at room temperature without protective diodes evidenced heat stains, while all cells that were tested at 2 A at 71°C without diodes evidenced heat

stains and/or case swelling. Twenty-five out of forty cells that were tested at 5 A without protective diodes evidenced heat stains and/or case swelling, while nine cells out of forty vented.

6.4.4 High Temperature Exposure Tests

High temperature exposure tests were conducted on ten fresh and ten discharged cells. The cells were exposed to a temperature of 149°C for one hour. There was no evidence of electrolyte leakage in any of the cells. The fresh cells were subsequently discharged at room temperature under 10 ohm loads, and then under 20 ohm loads. The cells delivered an average of 28.7 Ah to 1.5 volts under 10 ohm loads. Delta capacities were negligible as the cells were discharged to below 1.5 volts under 10 ohm loads.

6.4.5 Shock and Vibration Tests

Ten cells were subjected to shock and vibration testing, while an additional group of ten cells were subjected to shock testing only. The shock test was conducted with peak acceleration equal to 200 g's and duration equal to 0.5 milliseconds. The shock was applied in two directions along each of three mutually perpendicular axes for a total of six shocks. The random vibration test was conducted at three different levels (17.6, 20.1, and 24.9 GRMS), and applied for 15 minutes per axis at each level. The cells were subsequently discharged under 10 ohm loads at room temperature, and delivered an average of 28.0 Ah to 1.5 volts. A 20 ohm delta discharge was performed. The cells delivered negligible delta capacity as they were discharged below 1.5 volts under 10 ohm loads.

7. References

1. B. Bragg - private communication

2. W. Clark, S. Ebel, D. Eberhard, E. Takeuchi, Testing and Improvement of Lithium/BCX Cells, NASA Contract NAS 9-17821

8. Appendices

A. Specification for Acceptance Testing and Lot Certification of Li/BCX Cells and Batteries for Delivery to NASA Johnson Space Center

B. Lot Certification Test Results for NASA BCX 149 DD Cells Delivered to NASA Johnson Space Center

C. Temperature versus Time Graphs for Capacity Performance Test Cells

D. Quality Control Department Destructive Analysis Report 90-43-1

E. Short Circuit Test Report 90-014

F. Quality Control Department Destructive Analysis Reports 90-52-1 and 90-53-1

G. Charging Test Report 90-013

H. Overdischarge Test Report 90-016

I. MGA Research Corporation Shock and Vibration Test Report

Appendix A

Specification for Acceptance Testing and Lot Certification of Li/BCX Cells and Batteries for Delivery to NASA Johnson Space Center

SPECIFICATION FOR ACCEPTANCE TESTING AND LOT CERTIFICATION TESTING OF Li-BCX CELLS AND BATTERIES FOR DELIVERY TO NASA JOHNSON SPACE CENTER

1.0 SCOPE

The cells and batteries covered herein are those described in Appendix A hereto. Cells and batteries shall be manufactured according to the provisions of Electrochem Industries Quality Plan 17096.

2.0 ACCEPTANCE TESTS

The following tests shall be performed prior to the tests of 3.0 on every cell/battery submitted for delivery to NASA. Failure on any test or measurement for which pass/fail criteria are given shall result in rejection of the cell/battery which is nonconforming.

2.1 CELL X-RAYING

2.1.1 Prior to filling with electrolyte, each cell shall be X-rayed to examine its as-built internal configuration. Two views shall be taken. One view shall be perpendicular to the cylindrical side of the cell can and include the entire height of the cell. The other view shall be the same, except the cell shall be rotated about its axis 90°. It shall be permissible to make additional views of any cell in which there appears to be a defect not clearly depicted in the first two views.

2.1.2 X-ray inspection shall be performed per Electrochem Industries Quality Control Instruction 30.

2.1.3 Serialization

Prior to X-raying, and for the purpose of identifying each cell with its X-ray picture, each cell shall have an identifying number placed on its cylindrical surface with permanent marking ink in a place which does not overlap legends on the cell. The number, along with date/lot code legend, shall then be the unique identifying serial number of each cell.

2.2 160°F EXPOSURE

2.2.1 After cell assembly has reached the stage where the cells have been filled and sealed, but before addition of any further cell parts, all cells shall be placed in an appropriate heating chamber or oven in which the cell temperatures shall be brought to 160°F $\pm$10°F as measured by a thermocouple placed on the cylindrical surface of a cell. More than one thermocouple should be used if doubt exists as to uniformity of heating conditions in the chamber. When the cells

reached the above temperature control limits, they shall be kept there for a period of 2 ±0.1 hours. Cells shall then be permitted to cool to within 5°F ambient room temperature before the tests of 2.2.3 are performed. After cooling, examine each cell for any permanent deformation and for any damage to the glass hermetic seal. Reject deformed cells or cells with cracked or broken seals, or cells indicating any evidence of leakage.

2.2.2 In the instance of multi-cell batteries, this test shall be performed on the cells from which the batteries are to be made.

2.2.3 After completion of this test, all cells (including those to be assembled into batteries) shall have their assembly completed and shall then meet the following requirements by test or measurement.

2.2.3.1 Open circuit voltage (OCV) shall be 3.85 volts, minimum. Record OCV versus serial number of all cells in the lot.

2.2.3.2 Load test each cell using the applicable load listed in Appendix A for 90 ±10 seconds. At the end of this test, cell voltage shall be at least 3.50 volts on load.

(1) All cells yielding at least 3.50 volts have passed the test.

(2) Any cell yielding less than 3.40 volts is a failure and shall be rejected.

(3) Any cell yielding a voltage less than 3.50 volts, but not less than 3.40 volts, shall be subjected to retest after a minimum wait of 3 hours. If the voltage yielded on retest is still less than 3.50 volts, the cell is a failure. No further retest is permitted.

(4) Record time to 3.50 volts and load voltage at 90 seconds versus serial numbers.

2.2.3.3 Diameter and length shall be within the tolerances shown on the drawing listed in Appendix A. The length dimension shall be measured along the central axis of the cell, including solder tabs if present. Record length and diameter by cell serial number.

2.2.3.4 The weight of each cell shall be within the tolerances shown in Appendix A. Record weight by cell serial number.

3.0 LOT CERTIFICATION

The following tests shall be passed successfully prior to acceptance by the Government and shall be performed on lot samples selected randomly in the quantities given in 3.2. Failure on any test for which pass/fail criteria are given shall result in lot rejection. Cells shall be completely assembled for this test, except as noted. Randomness of sample selection shall be assured by use of standard statistical methods.

3.1 CERTIFICATION LOT DEFINITION

For purposes of lot sampling and without regard to the manufacturer's system for date/lot coding of individual cells, the Certification Lot shall be all those cells which have been consecutively made within two consecutive calendar days using a single batch of electrolyte mix for filling. Additionally, the cells shall be made using one batch only of lithium anode material, cathode mix and separator material.

3.2 SAMPLE SIZES

The sample sizes for the various tests requiring unused samples are given below.

Test Paragraph	Test Title	Percent of Certification Lot in Sample*
3.3	Capacity Discharge	6%, but not less than 2 cells
3.4	High Temp. Exposure	6%, but not less than 2 cells
3.8	Short Circuit	4%, but not less than 1 cell
3.9	300°F Exposure	1 cell/lot
3,10	Vibration	4 cells/lot

* Percent calculations shall be rounded upward to the next integer.

3.3 CAPACITY DISCHARGE

The sample cells each shall be discharged through a constant resistance having the applicable value shown in Appendix A to a test end voltage of 2.0 volts, while at a temperature of 70°F ±10°F at ambient atmospheric pressure. The ampere-hours of capacity given by each cell shall be calculated, and the arithmetic average of the ampere-hour values determined. The average ampere-hours shall not be less than the minimum average value specified in Appendix A. All discharged samples shall subsequently be used in the Fuse Check Test of 3.6. All cell capacities shall be reported to NASA.

3.4 HIGH TEMPERATURE EXPOSURE

All cells shall be placed in an appropriate heating chamber or oven without touching each other. They shall be brought to a temperature of 200°F ±10°F as measured by a thermocouple placed on the cylindrical surface of a cell. More than one thermocouple should be used if doubt exists as to uniformity of heating conditions in the chamber. When the cells reach the above control limits, they shall be kept there for 2.0 ±0.1 hours. They shall then be allowed to cool to within 5°F of ambient room temperature before examination. They shall then be visually examined and shall exhibit no venting or leakage. To enhance the visual examination, this test shall be run with cells which have the cell headers exposed.

3.5 HIGH RATE DISCHARGE

Upon passing the High Temperature Exposure Test of 3.4, the sample cells from that test shall each be discharged through the resistance specified in Appendix A to a test end voltage of 2.0 volts, while at

a temperature of 70°F ±10°F at ambient atmospheric pressure. The ampere-hours of capacity given by each cell shall be calculated and reported to NASA. No pass/fail criterion applies to this test.

3.6 FUSE CHECK TEST

Upon passing the Capacity Discharge Test of 3.3, the sample cells from that test shall be subjected to the Fuse Check Test, below.

3.6.1 Remove the terminal cap and hot melt glue under the cap, exposing components under the cap, in a manner which results in no damage to the fuse. Verify that all components are present between the cell header and the terminal cap as specified in the drawing cited in the purchase order or contract. If any part is missing, the lot shall be rejected.

3.6.2 Using a constant current power supply, pass an amount of current equal to twice the fuse rating through the fuse. The fuse shall blow within 15 seconds of application of current. The power supply connections should be made at the positive terminal post and the terminal cap, thus including the fuse in a circuit external to the cell. Failure of a fuse to blow as above shall result in failure of the lot.

3.6.3 The cells shall then be used in performing the Overdischarge Tests of 3.7.

3.7 OVERDISCHARGE CAPABILITY TESTS

3.7.1 Take the same cells as in 3.6 (first 6% of each lot but at least two (2) cells) and store them at room ambient temperature for 3 ±1 weeks. After the storage period, place the cells on overdischarge according to the table below. Use a constant current power supply in series with each cell as the driving force for overdischarge. Bypass the integral cell fuse for these tests and install a shunt diode on each cell. For the 160°F tests, the cells may be overdischarged in series up to 15 cells at one time.

CELL SIZE AND DIODE NUMBER	NUMBER OF CELLS PER TEST	CONSTANT OVERDISCHARGE CURRENT (amperes)	OVERDISCHARGE DURATION (hours)	TEST TEMP (°F)
AA IN5817	1	2 ±0.1	Until a minimum of two hours has elapsed at a negative cell voltage.	Room Temp
	Rest of first 6% but at least 1	0.1 ±0.01	16 $^{+0.5}_{-0}$ then 16 additional hours with diodes removed.	160°F
C IN5820	1	3 ±0.1	Until a minimum of two hours has elapsed at a negative cell voltage.	Room Temp
	Rest of first 6% but at least 1	0.3 ±0.01	16 $^{+0.5}_{-0}$ then 16 additional hours with diodes removed.	160°F
D IN5820	1	3 ±0.1	Until a minimum of two hours has elapsed at a negative cell voltage.	Room Temp
	Rest of first 6% but at least 1	1.0 ±0.01	16 $^{+0.5}_{-0}$ then 16 additional hours with diodes removed.	160°F
DD IN5823	1	4.7 ±0.1	Until a minimum of two hours has elapsed at a negative cell voltage.	Room Temp
	Rest of first 6% but at least 1	3.0 ±0.1	16 $^{+0.5}_{-0}$ then 16 additional hours with diodes removed.	160°F

3.7.2 If any of the cells tested at 160°F vents or explodes during the first 16 hours of overdischarge while protected with a shunt diode, the lot shall be rejected and a failure analysis performed by the manufacturer. The test of single cells at room temperature and the additional 16-hour test at 160°F without shunt diode protection are for information and have no pass/fail criteria.

3.8 SHORT CIRCUIT TESTS

Sample cells selected for this test per 3.2 (4% of lot) shall have their integral fuses bypassed and be short-circuit tested in suitable, protective chamber as follows.

3.8.1 Mount the cell by fastening it down lengthwise in a piece of angle iron of the size given below, mounted to the chamber door. Place the cell close to the door.

Cell Size	Angle Iron Size
AA	1" x 1" x 1/8" x 12"
C	1-1/2" x 1-1/2" x 3/16" x 12"
D & DD	2" x 2" x 1/4" x 12"

3.8.2 Condition the cell to a temperature of 75° ±10°F, measured on the cylindrical surface of the case. Subject the cell to a resistance load between 35 and 50 milliohms. The resistance shall be the minimum value which will not fuse internal plate tab connections. Record cell voltage, current and temperature from the time 5 seconds before switching on the load until test end (given below). The record of at least the first 5 minutes should be on a strip chart.

3.8.3 Terminate load when cell temperature ceases to rise for at least 5 minutes.

3.8.4 After the cell temperatures have declined to 85°F or below, open the chamber and examine the cells for evidence of venting, leaking, bulging or other non-nominal condition. The cells shall not vent or leak on this test.

3.9 300°F Exposure Test

The sample cell shall be in the same configuration as cells subjected to the 160°F exposure test of 2.2. Place the cell in a thermal chamber and raise the chamber temperature to 300°F ±5°F at a rate not to exceed 5°F per minute. When 300°F ±5°F is reached, as determined by a thermocouple on the test cell, maintain temperature for a minimum of fifteen (15) minutes. Then allow the temperature to decrease back to 90°F or less. Examine the cell visually and examine the glass-to-metal hermetic glass seal under at least seven power (7x) magnification. The cell may exhibit permanent bulging, but there shall be no evidence of electrolyte leakage anywhere on the cell, especially at the glass seal and at welds. Evidence of electrolyte leakage shall result in rejection of the lot.

3.10 Vibration

a. Subject the sample cells to random vibration according to the following spectrum for 15 minutes in each of 3 mutually perpendicular axes:

Frequency (Hz)	Level
20 to 80	+3 db/octave
80 to 350	$0.10g^2$/Hz
350 to 2000	-3 db/octave

b. Continuously record open circuit voltage of each cell for a time period beginning 5 seconds (or more) before starting vibration and ending 30 ±5 seconds after completion of vibration in all three axes. After the observation period, perform the load test of 2.2.3.2.

c. The open circuit voltage of any cell shall not change during the observation period of b., above. Cells shall meet the applicable pass/fail criteria of the load test of 2.2.3.2.

3.11 REPORTING

For each lot subjected to the Acceptance and Lot Certification tests, the manufacturer shall forward to NASA a short report in the format outlined in Appendix B showing the results of each test performed.

APPENDIX A

Cell/Battery Size (ANSI)	WGL Dwg. No. (2.2.4.3)	Capacity Discharge Load-Ohms (3.3)	High Rate Discharge Load-Ohms (3.5)	Load Check Ohms (2.2.4.2)	Minimum Average Capacity Required Amp-hrs (3.3)	Allowable Weight Grams (2.2.3.4)	Cell Diameter Inches (nom.)	Cell Length Inches (nom.)
AA	3B39	182	30	30	1.8	16.05 ±0.45	0.54	1.92
C	3B2075-XA	75	6	10	6.0	52 ±2	1.009	1.91
D	3B1910-XA	20	3	5	13.0	114 ±2	1.32	2.34
2D	3PD310*	40	6	10	13.0	227 ±5	1.32	4.89
DD	3B2085-XA	10	1.5	2.25	25.0	212 ±4	1.32	4.38

* Cell Drawings are 3B1910XB and 3B1910XC, for purposes of certain acceptance tests done at cell level.

NOTES:

1. Drawings will bear a revision letter as shown on the NASA order/contract, unless otherwise approved by the NASA Contracting Officer in writing.

2. All resistances shall have a tolerance not exceeding ±1% of the nominal value.

3. Applicable test paragraph numbers are shown in parentheses in the title blocks.

APPENDIX B

OUTLINE OF LOT CERTIFICATION TEST REPORT

1.0 ACCEPTANCE TEST (2.0)

1.1 Serialization (2.1.3)

a. Lot number and quantity (each cell size)
b. Serial number (each cell)

1.2 X-rays (2.1)

a. Cell X-rays with serial numbers (2-views per cell minimum)
b. Date X-rays taken
c. Statement of examination results

1.3 160°F Exposure (2.2)

a. Data Sheet (approved) showing temperature exposure and thermocouple location (2.2.1)
b. Cell voltage (OCV) and serial number (S/N) (2.2.3.1)
c. Cell S/N, time load voltage reached 3.50 V and load voltage at 90 +10 seconds (2.2.3.2)
d. Cell S/N, diameter, length and weight (2.2.3.3 and 2.2.3.4)

2.0 LOT CERTIFICATION (3.0)

2.1 Lot Definition (3.1)

a. Lot number and quantity
b. Manufacturing date(s)

2.2 Capacity Discharge Test (3.3)

a. Date(s) of test
b. Sample size and cell S/N
c. Minimum average capacity requirement
d. Average capacity obtained
e. Individual cell capacities (attachment)

2.3 High Temperature Exposure (3.4)

a. Date(s) of test
b. Sample size and S/N
c. Test results (no leaks or vents, or quantity of leaks or vents)

2.4 High Rate Discharge (3.5)

a. Date(s) of test
b. Load used
c. Individual cell capacities (attachment) by S/N

2.5 Fuse Check Test (3.6)

a. Date(s) of test
b. Results of test (all pass or quantity failed)

2.6 Overdischarge Test (3.7)

a. Date(s) of test
b. Results of room temperature test
c. Results of 160°F test with diodes;

(1) No venting, or
(2) Quantity vented and duration of exposure at time of venting (attachment)

d. Results of 160°F continuation test without diodes;

(1) No venting, or
(2) Quantity vented and duration of exposure at time of venting (attachment)

2.7 Short Circuit Test (3.8)

a. Date(s) of test
b. Sample size and S/N
c. Peak current reached on each cell (attachment)
d. Temperature rise on each cell (attachment)
e. Time to reach peak current and peak temperature

2.8 Vibration Test (3.10)

a. Date(s) of test
b. Sample size and S/N's
c. Open circuit voltage during vibration test
d. Load voltage and load used
e. High rate discharge load and individual cell capacities (attachment)

2.9 300°F Exposure Test (3.9)

a. Date(s) of test
b. Cell S/N
c. Description of cell after test

2.10 Copies of all failure/discrepancy reports with material review action on each.

2.11 Certification by the manufacturer's quality assurance manager that all testing was performed according to requirements of this specification, and that this report is complete and accurate.

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APPENDIX A

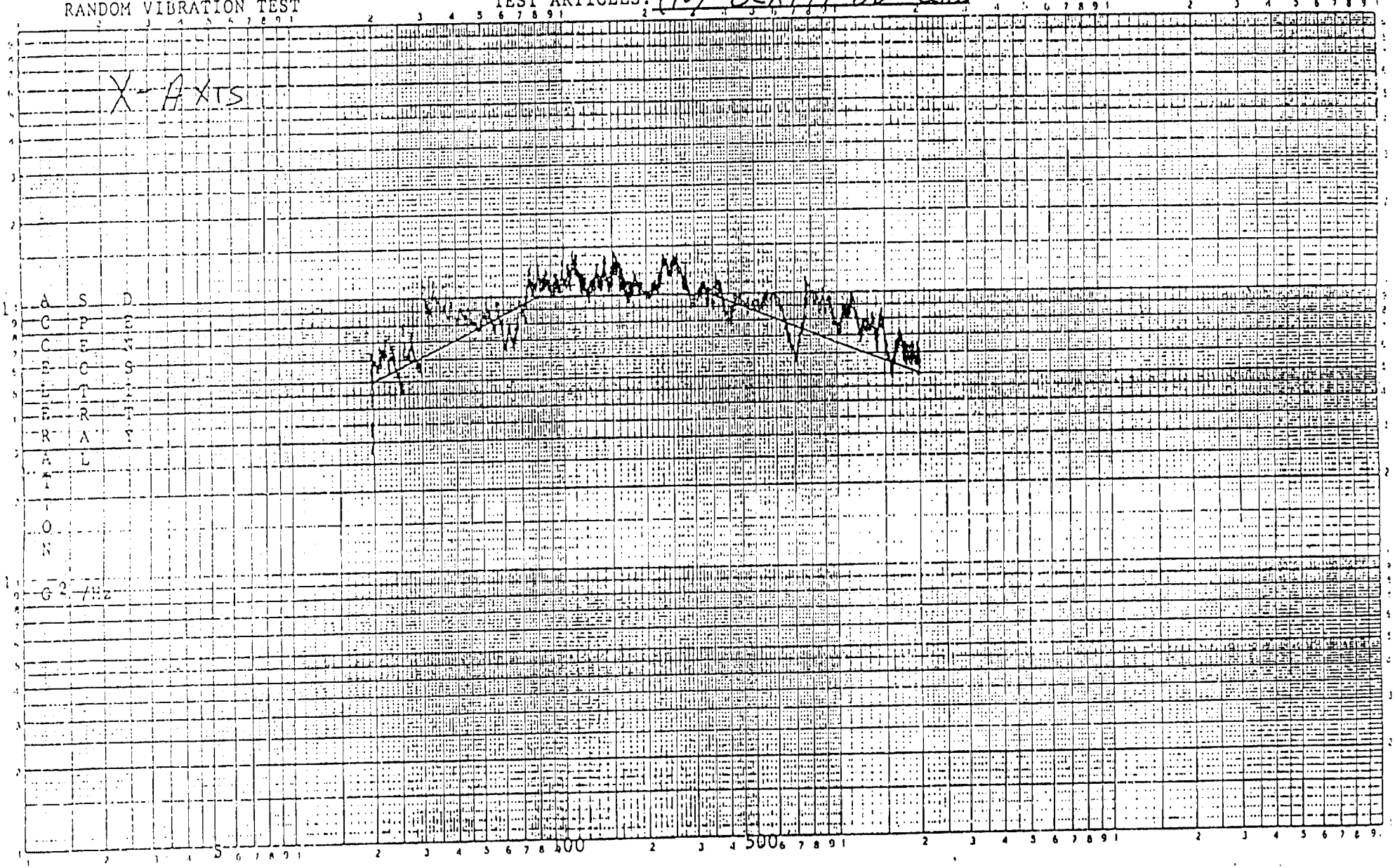
TEST DATA SHEETS

WILSON GREATBATCH LTD.

DATE: 8/18/89

RANDOM VIBRATION TEST

TEST ARTICLES: (16) BCX149 "DD" Cells



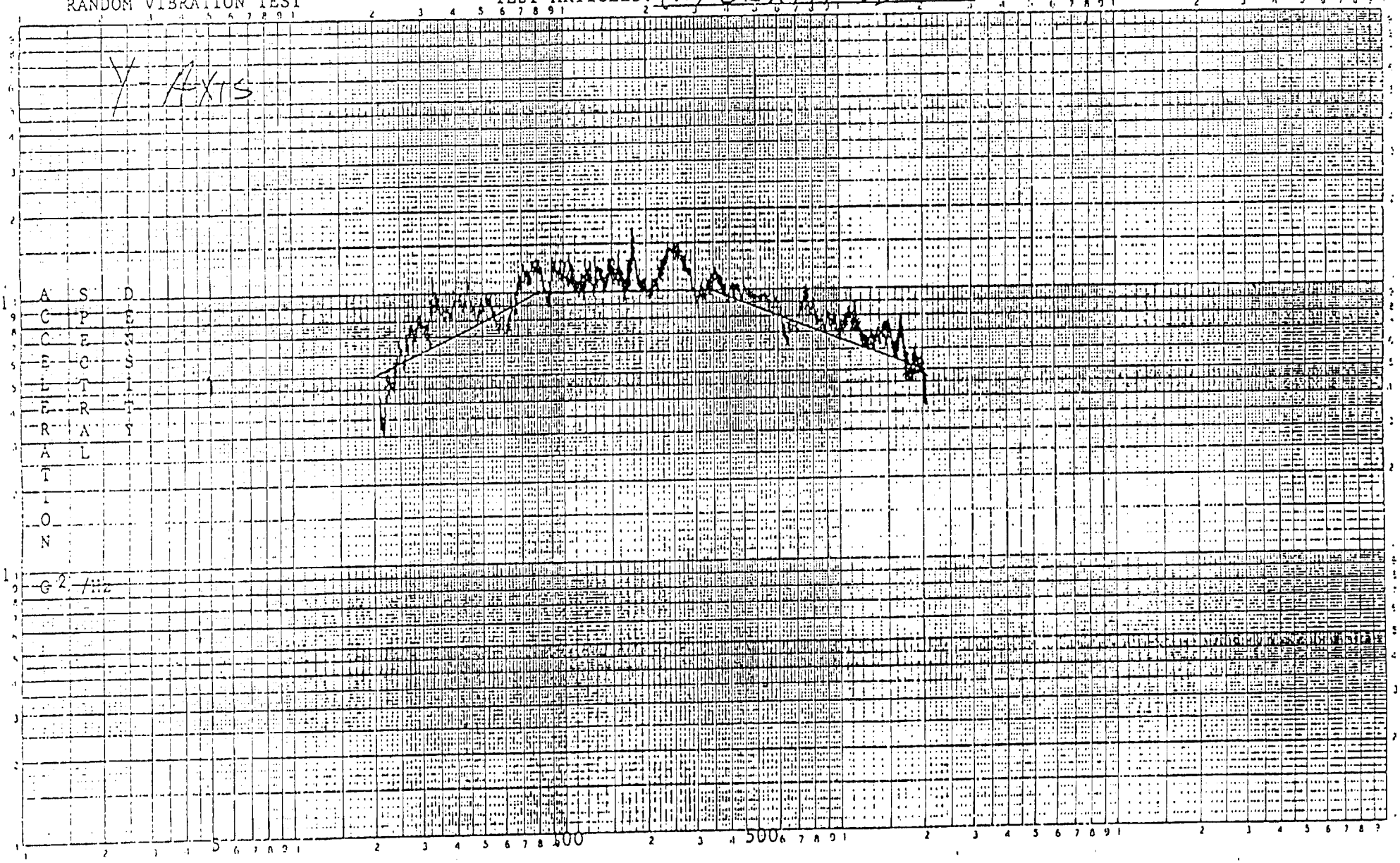
WILSON GREATBATCH LTD.

RANDOM VIBRATION TEST

TEST ARTICLES: (16) BCX149 "DD" Cells

DATE: 8/18/89

Y - AXIS



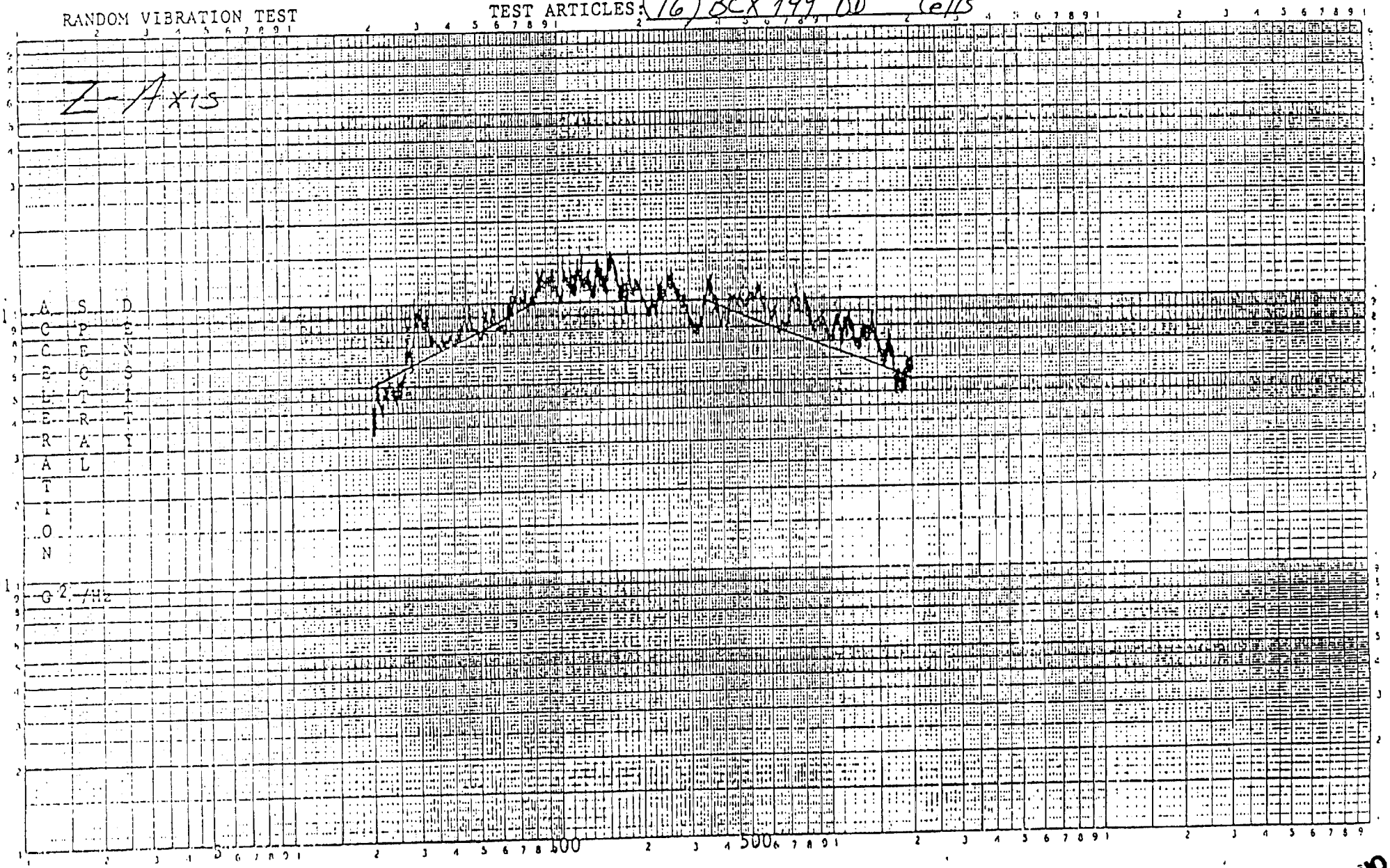
WILSON GREATBATCH LTD.

DATE: 8/18/89

RANDOM VIBRATION TEST

TEST ARTICLES: (16) BCX 149 "DD" Cells

Z-Axis



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Appendix B

Lot Certification Test Results for NASA BCX 149 DD Cells Delivered to NASA Johnson Space Center

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RELIABILITY TEST RESULTS

MODEL: NASA BCX149DD PN 3B2085-XA	DATE: 17AUG89	REPORT NO: 89/069

TEST: SHORT-CIRCUIT

PURPOSE: Originator - S. Meyer (REF: E.I/TR# 89-111)

The purpose of this test is to satisfy the requirements of the NASA contract NAS9-18142 with respect to lot certification testing as per para 3.8 of NASA JSC document EP5-83-025, Rev B.

PARAMETERS:

Twenty-seven cells were submitted for test. The cells were short-circuit tested as per para 3.8 of NASA JSC document EP5-83-025. A 33 milliohm resistor was placed in series with the cell to raise the resistance of the short-circuit to 35 to 50 milliohms as specified. Cell voltage, current, and skin temperature were monitored and recorded. Cells were visually examined after test.

TEST RESULTS: Refer to attached test table (Figure 1).

KEYWORDS: Short-Circuit

SUBMITTED BY: T Humphreys	DATE: 21 Aug 89
APPROVED BY: R C Stanley	DATE: 22 Aug 89
ISTRIBUTION: B. Webster, S.Meyer, G.Ludwig, P.Krehl	PAGE 1 OF 4

FORM NO. 7044/0783 "REV A"

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY D.Crosley, L.Parker

CHEMISTRY: LI/BCX

FIGURE 1

SHORT CIRCUIT TEST AT ROOM TEMPERATURE

(WITH .033 OHM RESISTOR IN SERIES)

NASA - BCX149DD - UNFUSED (PN 3B2085-XA)

[X] COMMERICAL
[ ] MEDICAL
[ ] OTHER

SERIAL NUMBER	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
6	D249C	3.93	25.7	0:02	THERMO. DISATTACHED - CELL REACHED 154.5 IN 15 MIN 3 SEC AFTER SHORT WAS CREATED.		NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
1	E249A	3.93	25.6	0:02	141.5	15:18	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
3	E249A	3.92	26.0	0:01	154.5	15:27	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
37	E249B	3.93	24.5	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 2.5 SEC AFTER SHORT WAS CREATED.
12	E249B	3.92	25.3	0:01	144.0	11:51	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
7	D249C	3.92	26.0	0:02	138.0	12:54	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
20	D249C	3.92	21.8	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 4 SEC AFTER SHORT WAS CREATED.
41	D249B	3.92	23.0	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 2 SEC AFTER SHORT WAS CREATED.
41	D249A	3.92	22.9	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 15 SEC AFTER SHORT WAS CREATED.
							RTR# 89/069

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY D.Crosley, L.Parker

CHEMISTRY: LI/BCX

FIGURE 1

SHORT CIRCUIT TEST AT ROOM TEMPERATURE

(WITH .033 OHM RESISTOR IN SERIES)

NASA - BCX149DD - UNFUSED (PN 3B2085-XA)

[X] COMMERICAL
[ ] MEDICAL
[ ] OTHER

SERIAL NUMBER	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
14	D249A	3.92	22.8	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 6 SEC AFTER SHORT WAS CREATED.
29	D249A	3.92	24.8	0:03	51.0	4:00	LOSS OF INTERNAL CONTINUITY APPROX. 31 SEC AFTER SHORT WAS CREATED.
41	C249C	3.93	25.5	0:21	173.5	23:00	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
41	C249B	3.93	25.8	0:02	39.0	3:03	LOSS OF INTERNAL CONTINUITY APPROX. 30 SEC AFTER SHORT WAS CREATED.
46	B249C	3.93	23.4	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 2.5 SEC AFTER SHORT WAS CREATED.
22	B249C	3.93	23.6	0:05	120.0	21:03	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
4	B249B	3.92	25.2	0:04	61.5	4:12	LOSS OF INTERNAL CONTINUITY APPROX. 32 SEC AFTER SHORT WAS CREATED.
41	B249B	3.92	24.5	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 12 SEC AFTER SHORT WAS CREATED.
31	B249A	3.93	25.0	0:02	47.0	3:57	LOSS OF INTERNAL CONTINUITY APPROX. 1MIN 48 SEC AFTER SHORT WAS CREATED.

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY D.Crosley, L.Parker

CHEMISTRY: LI/BCX

FIGURE 1

SHORT CIRCUIT TEST AT ROOM TEMPERATURE

(WITH .033 OHM RESISTOR IN SERIES)

NASA - BCX149DD - UNFUSED (PN 3B2085-XA)

☒ COMMERICAL
☐ MEDICAL
☐ OTHER

SERIAL NUMBER	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
33	B249A	3.93	25.0	0:03	152.5	18:54	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
8	A249B	3.93	23.2	0:16	90.5	195:30	LOSS OF INTERNAL CONTINUITY APPROX. 33 SEC AFTER SHORT WAS CREATED.
33	A249B	3.93	24.7	0:05	65.0	5:24	LOSS OF INTERNAL CONTINUITY APPROX. 33 SEC AFTER SHORT WAS CREATED.
21	A249A	3.93	24.6	<0:01	NO SIGNIFICANT TEMPERATURE RISE		LOSS OF INTERNAL CONTINUITY APPROX. 2 SEC AFTER SHORT WAS CREATED.
16	A249A	3.93	27.2	0:04	43.5	4:06	LOSS OF INTERNAL CONTINUITY APPROX. 30 SEC AFTER SHORT WAS CREATED.
15	A299A	3.94	22.7	<0:01	165.5	45:27	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
40	A299A	3.94	24.5	<0:01	85.5	172:42	LOSS OF INTERNAL CONTINUITY APPROX. 5 MIN 42 SEC AFTER SHORT WAS CREATED.
27	A299B	3.94	22.0	<0:01	160.0	65:45	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
8	A299B	3.94	22.0	1:30	199.0	43:12	NO VENT OR RUPTURE. BOTTOM OF CASE SWELLED.
							RTR# 89/069 PAGE 4 OF 4

NASA LOT CERTIFICATION SEQUENCE

P/N 3B2085-XA CCD Rev - NASA CONTRACT NAS 9-18142

CERTIFICATION LOT # 1 DATE CODES A249A, A249B

PASSED ATP
(X-RAY, 160° OVEN, OCV, LOAD, DIAMETER, LENGTH, WEIGHT)

LOT CERTIFICATION SAMPLE
n = 21

n = 1
300° F EXPOSURE TEST
No leakage
☒ Pass ☐ Fail

n = 5
CAPACITY DISCHARGE
10 Ohm load
Ave. Ah = 25 Ah. minimum
n = 30
Discharge curves attached

n = 6
FUSE CHECK
Must blow within 15 sec. at 10 Amps.
No. Failed 0

n = 6
HIGH TEMP. EXPOSURE
Headers Exposed
200°F ± 10° for 2 ± 0.1 Hr.
No Vent or Leakage
No. Failed 0

n = 6
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

n = 4
SHORT CIRCUIT
No Vent or Leakage
No. Failed 0

n = 4
VIBRATION
No change in OCV
Load voltage = 3.5V min. after 90 ±10 sec.
No. Failed 0

n = 4
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

OVERDISCHARGE STORAGE CONDITIONING
3 ± 1 Wk. @ Rm. Temp.
FORWARD @ LATER DATE ✓

n = 1
OVERDISCHARGE
High Current Rm. Temp. with Diode Shunt for 2 hrs at Neg. Voltage
No pass/fail criteria

n = 5
OVERDISCHARGE
Low current @ 160°F with Diode Shunt for 16 hours.
NO Vent or Rupture
No. Failed 0

n = 5
OVERDISCHARGE
Low current @ 160°F without Diode Shunt for 16 hours.
NO pass/fail criteria

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TEST REPORT FOR CERTIFICATION LOT # 1 PART No 3B2085-XA Rev -
Contract No. NAS 9-18142

1.1 SERIALIZATION

a) Date Codes and Serial Numbers: A249B - 1, 2, 3, 5, 7, 10, 13, 14, 17, 18, 20, 21, 23, 25, 27, 29, 30, 31, 37, 41, 42, 43, 45, 48
A249A - 1, 2, 4, 6, 20, 25, 26, 27, 28, 29, 30, 33, 34, 40, 44, 46, 47, 48

1.2 X-RAYS

a) See x-rays in separate package.
b) Date of x-ray: 14 JUNE 89

1.3 160°F EXPOSURE

a) Chart and thermocouple locations: See recorder chart attached.
b), c) and d) OCV, Load Voltage, Dimensions: See separate report 3-3115/0489.

2.1 LOT DEFINITION

a) Battery or Cell Type 3B2085-XA Rev -
b) Electrolyte Lot Number: 89160-01
c) Date Codes: A249A, A249B
d) Pour Dates: 15 JUNE 89

2.2 CAPACITY DISCHARGE TEST

a) Date(s) of Test: 14 July 89
b) Sample Size: 6
c) Minimum Average Capacity Requirement: 25 AH
d) Average Capacity Obtained: 30 AH
e) Load Used: 10 OHM
f) Individual Cell Capacities: Rundown Test Curves Attached
g) Date Codes and Serial Numbers: A249A - 18, 23, 3
A249B - 15, 32, 12

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LOT CERTIFICATION TEST REPORT 36208S-XA Rev -
Ref PS28/ATP-08001/B
Contract No. NAS 9-17540

2.3 HIGH TEMPERATURE EXPOSURE
a) Date(s) of Test: 14 JUL 89
b) Sample Size: 6
c) Test Results: ACCEPTABLE
d) Date Codes and Serial Numbers: A249A-14, 39, 48
A249B-6, 35, 36

2.4 HIGH RATE DISCHARGE
a) Date(s) of Test: 17 JULY 89
b) Sample Size: 6
c) Average Capacity Obtained: 27 AH
d) Load Used: 1.5 OHM
e) Individual Cell Capacities: Rundown Test Curves Attached
f) Date Codes and Serial Numbers: A249A-14, 39, 48
A249B-6, 35, 36

2.5 FUSE CHECK TEST
a) Date(s) of Test: 22 AUG. 89
b) Sample Size: 6
c) Result of Test: ACCEPTABLE
d) Date Codes and Serial Numbers: A249A-18, 23, 3
A249B-15, 32, 12

2.6 OVERDISCHARGE TEST — FORWARD @ LATER DATE ✓
a) Date(s) of Test: 14 Aug. 89
b) Sample Size: 6
c) Result of RT Test: ACCEPTABLE
d) Result of 160°F Test With Diodes: ACCEPTABLE
e) Result of 160°F Test Without Diodes: NO PHYSICAL CHANGE
f) Date Codes and Serial Numbers: A249A-23 / A249A-18, 3,
A249B-12, 32, 15,

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LOT CERTIFICATION TEST REPORT 382085-XA Rev -
Ref PS28/ATP-08001/B
Contract No. NAS 9-17540

2.7 SHORT CIRCUIT TEST

a) Date(s) of Test: 17 Aug. 89
b) Sample Size: 4
c) Peak Current, Each Cell: See Attachment
d) Temperature Rise on Each Cell: See Attachment
e) Result of Test: ACCEPTABLE
f) Date Codes and Serial Numbers: A249A - 16, 21,
A249B - 8, 33,

2.8 VIBRATION TEST

a) Date(s) of Test: 18 Aug. 89
b) Sample Size: 4
c) Result of Test: ACCEPTABLE Attach Report From Testing Vendor
d) Date Codes and Serial Numbers: A249A - 32, 41
A249B - 46, 22

2.9 300°F EXPOSURE TEST

a) Date of Test: 10 Aug. 89
b) One Unfinished (unfused) Cell
c) Result of Test: ACCEPTABLE
d) Cell Date Code and Serial Number: A249A - 11,

NASA LOT CERTIFICATION SEQUENCE

P/N 3B2085-XA CCD Rev - NASA CONTRACT NAS 9-18142

CERTIFICATION LOT # 2 DATE CODES B249A, B249B, B249C

PASSED ATP
(X-RAY, 160° OVEN, OCV, LOAD, DIAMETER, LENGTH, WEIGHT)

LOT CERTIFICATION SAMPLE
n = 29

n = 1
300° F EXPOSURE TEST
No leakage
☑ Pass ☐ Fail

n = 9
CAPACITY DISCHARGE
10 Ohm load
Ave. Ah = 25 Ah. minimum
= 30
Discharge curves attached

n = 9
FUSE CHECK
Must blow within 15 sec. at 10 Amps.
No. Failed 0

n = 9
HIGH TEMP. EXPOSURE
Headers Exposed
200°F ± 10° for 2 ± 0.1 Hr.
No Vent or Leakage
No. Failed 0

n = 9
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

n = 6
SHORT CIRCUIT
No Vent or Leakage
No. Failed 0

n = 4
VIBRATION
No change in OCV
Load voltage = 3.5V min. after 90 ± 10 sec.
No. Failed 0

n = 4
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

OVERDISCHARGE STORAGE CONDITIONING
3 ± 1 Wk. @ Rm. Temp.
— FORWARD @ LATER DATE ✓

n = 1
OVERDISCHARGE
Hi Current Rm. Temp. with Diode Shunt for 2 hrs at Reg. Voltage
No pass/fail criteria

n = 8
OVERDISCHARGE
Low current @ 160°F with Diode Shunt for 16 hours.
NO Vent or Rupture
No. Failed 0

n = 8
OVERDISCHARGE
Low current @ 160°F without Diode Shunt for 16 hours.
NO pass/fail criteria

TEST REPORT FOR CERTIFICATION LOT - 2 PART No 3B2085-XA Rev -
Contract No. NAS 9-18142

1.1 SERIALIZATION

a) Date Codes and Serial Numbers: B249A - 4, 6, 7, 12, 19, 25, 27, 28, 32, 35, 36, 37, 38, 40, 42, 44, 46,
B249B - 2, 5, 7, 9, 10, 13, 14, 17, 19, 23, 24, 26, 30, 33, 34, 36, 40, 46, 48,
B249C - 3, 4, 6, 10, 11, 16, 20, 27, 36, 38, 40, 42, 43, 44, 45

1.2 X-RAYS

a) See x-rays in separate package.
b) Date of x-ray: 15-16 JUNE 89

1.3 160°F EXPOSURE

a) Chart and thermocouple locations: See recorder chart attached.
b), c) and d) OCV, Load Voltage, Dimensions: See separate report 3-3115/0489.

2.1 LOT DEFINITION

a) Battery or Cell Type 3B2085-XA Rev -
b) Electrolyte Lot Number: 89160-01
c) Date Codes: B249A, B249B, B249C
d) Pour Dates: 16 JUNE 89

2.2 CAPACITY DISCHARGE TEST

a) Date(s) of Test: 14 July 89
b) Sample Size: 9
c) Minimum Average Capacity Requirement: 25 AH
d) Average Capacity Obtained: 30 AH
e) Load Used: 10 OHM
f) Individual Cell Capacities: Rundown Test Curves Attached
g) Date Codes and Serial Numbers: B249A - 14, 26, 41,
B249B - 6, 22, 29, B249C - 15, 35, 18

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LOT CERTIFICATION TEST REPORT 362085-XA Rev -
Ref PS26/ATP-08001/B
Contract No. NAS 9-17540

2.3 HIGH TEMPERATURE EXPOSURE
a) Date(s) of Test: 14 July 89
b) Sample Size: 9
c) Test Results: ACCEPTABLE
d) Date Codes and Serial Numbers: B249A-13, 18, 21, B249B-1, 15, 38, B249C-13, 28, 34,

2.4 HIGH RATE DISCHARGE
a) Date(s) of Test: 17 July 89
b) Sample Size: 9
c) Average Capacity Obtained: 26 AH
d) Load Used: 15 OHM
e) Individual Cell Capacities: Rundown Test Curves Attached
f) Date Codes and Serial Numbers: B249A-13, 18, 21, B249B-1, 15, 38, B249C-13, 28, 34,

2.5 FUSE CHECK TEST
a) Date(s) of Test: 22 Aug. 89
b) Sample Size: 9
c) Result of Test: ACCEPTABLE
d) Date Codes and Serial Numbers: B249A-14, 26, 41, B249B-6, 22, 29, B249C-15, 35, 18,

2.6 OVERDISCHARGE TEST — FORWARD @ LATER DATE ✓
a) Date(s) of Test: 16 Aug. 89
b) Sample Size: 9
c) Result of RT Test: ACCEPTABLE
d) Result of 160°F Test With Diodes: ACCEPTABLE
e) Result of 160°F Test Without Diodes: NO PHYSICAL CHANGE
f) Date Codes and Serial Numbers: B249A-14 / B249A-26, 41, B249B-6, 22, 9, B249C-15, 35, 18,

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LOT CERTIFICATION TEST REPORT 3B2085-XA Rev -
Ref PS28/ATP-08001/B
Contract No. NAS 9-17540

2.7 SHORT CIRCUIT TEST

a) Date(s) of Test: 17 Aug 89
b) Sample Size: 6
c) Peak Current, Each Cell: See Attachment
d) Temperature Rise on Each Cell: See Attachment
e) Result of Test: ACCEPTABLE
f) Date Codes and Serial Numbers: B249A-31,33, B249B-4,41 B249C-22,46

2.8 VIBRATION TEST

a) Date(s) of Test: 18 Aug 89
b) Sample Size: 4
c) Result of Test: ACCEPTABLE Attach Report From Testing Vendor
d) Date Codes and Serial Numbers: B249A-17, B249B-3,25, B249C-24,

2.9 300°F EXPOSURE TEST

a) Date of Test: 10 Aug. 89
b) One Unfinished (unfused) Cell
c) Result of Test: ACCEPTABLE
d) Cell Date Code and Serial Number: B249A-5,

NASA LOT CERTIFICATION SEQUENCE

P/N 382085-XA CCD Rev - NASA CONTRACT NAS 9-18142

CERTIFICATION LOT # 3 DATE CODES CJ49B, CJ49C, DJ49A, DJ49B, DJ49C, EJ49A EJ49B

PASSED ATP
(X-RAY, 160° OVEN, OCV, LOAD, DIAMETER, LENGTH, WEIGHT)

LOT CERTIFICATION SAMPLE n = 58

n = 1
300° F EXPOSURE TEST
No leakage
☑ Pass ☐ Fail

n = 20
CAPACITY DISCHARGE
10 Ohm load
Ave. Ah = 25 Ah. minimum
n = 30
Discharge curves attached

n = 20
HIGH TEMP. EXPOSURE
Headers Exposed
200°F ± 10° for 2 ± 0.1 Hr.
No Vent or Leakage
No. Failed 0

n = 13
SHORT CIRCUIT
No Vent or Leakage
No. Failed 0

n = 4
VIBRATION
No change in OCV
Load voltage = 3.5V min. after 90 ±10 sec.
No. Failed 0

n = 20
FUSE CHECK
Must blow within 15 sec. at 10 Amps.
No. Failed 0

n = 20
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

n = 4
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

OVERDISCHARGE STORAGE CONDITIONING
3 ± 1 Wk. @ Rm. Temp.
FORWARD @ LATER DATE ✓

n = 1
OVERDISCHARGE
Hi Current Rm. Temp. with Diode Shunt for 2 hrs at Neg. Voltage
No pass/fail criteria

n = 19
OVERDISCHARGE
Low current @ 160°F with Diode Shunt for 16 hours.
NO Vent or Rupture
No. Failed 0

n = 19
OVERDISCHARGE
Low current @ 160°F without Diode Shunt for 16 hours.
NO pass/fail criteria

TEST REPORT FOR CERTIFICATION LOT # 3 PART No 3B2085-XA Rev -
Contract No. NAS 9-18142

1.1 SERIALIZATION

a) Date Codes and Serial Numbers: CJ49B - 1,5,8,13,17,20,23,25,26,27, 28,31,33,36,37,39,40,43,44,45 / CJ49C - 2,3,5,6,7,12,13,15,19,23,25, 30,35,37,42 / DJ49A - 16,20,22,24,37,38,43,45,46 / DJ49B - 5,6,7, 10,11,14,16,18,19,20,23,31,34,40 / DJ49C - 11,21,27,37,38,40,42, 43,45,48 / EJ49A - 5,6,7,8,10,11,13,18,20,27,30,33 / EJ49B - 1,2, 5,6,7,8,9,10,11,14,20,21,22,23,25,26,29,31,33,34,40,41,44,45,

1.2 X-RAYS

a) See x-rays in separate package.
b) Date of x-ray: 19,20,21 JUNE 89

1.3 160°F EXPOSURE

a) Chart and thermocouple locations: See recorder chart attached.
b), c) and d) OCV, Load Voltage, Dimensions: See separate report 3-3115/0489.

2.1 LOT DEFINITION

a) Battery or Cell Type 3B2085-XA Rev -
b) Electrolyte Lot Number: 89160-01
c) Date Codes: CJ49B, CJ49C, DJ49A, DJ49B / DJ49C, EJ49A, EJ49B
d) Pour Dates: 20 JUNE 89 / 21 JUNE 89

2.2 CAPACITY DISCHARGE TEST

a) Date(s) of Test: 14 July 89
b) Sample Size: 20
c) Minimum Average Capacity Requirement: 25 AH
d) Average Capacity Obtained: 30
e) Load Used: 10 OHM
f) Individual Cell Capacities: Rundown Test Curves Attached
g) Date Codes and Serial Numbers: CJ49B - 18,4,16 / CJ49C - 33,45,29, DJ49A - 30,47,23, DJ49B - 12,18, / DJ49C - 16,41,24 / EJ49A - 45,15,21, EJ49B - 43,16,4,

LOT CERTIFICATION TEST REPORT 3B2085-XA Rev -
Ref P528/ATP-08001/B
Contract No. NAS 9-17540

2.3 HIGH TEMPERATURE EXPOSURE
a) Date(s) of Test: 14 JULY 89
b) Sample Size: 20
c) Test Results: ACCEPTABLE
d) Date Codes and Serial Numbers: C249B- 7,34,38, C249C-1,16,39,
D249A-25,33,40, D249B-8,38, D249C-28,31,44, E249A-16,22,25, E249B-13,17,36,

2.4 HIGH RATE DISCHARGE
a) Date(s) of Test: 17 July 89
b) Sample Size: 20
c) Average Capacity Obtained: 26 AH
d) Load Used: 1.5 OHM
e) Individual Cell Capacities: Rundown Test Curves Attached
f) Date Codes and Serial Numbers: C249B-7,34,38 C249C-1,16,39,
D249A-25,33,40, D249B-8,38, D249C-28,31,44, E249A-16,22,25, E249B-13,17,36,

2.5 FUSE CHECK TEST
a) Date(s) of Test: 22 Aug. 89
b) Sample Size: 20
c) Result of Test: ACCEPTABLE
d) Date Codes and Serial Numbers: C249B-18,4,16, C249C-33,45,29,
D249A-30,47,23, D249B-12,28, D249C-16,41,24, E249A-45,15,21, E249B-43,16,4,

2.6 OVERDISCHARGE TEST — FORWARD @ LATER DATE ✓
a) Date(s) of Test: 17, 21, Aug. 89
b) Sample Size: 20
c) Result of RT Test: ACCEPTABLE
d) Result of 160°F Test With Diodes: ACCEPTABLE
e) Result of 160°F Test Without Diodes: NO PHYSICAL CHANGE
f) Date Codes and Serial Numbers: D249A-23, / C249B-18,4,16,
C249C-33,45,29, D249A-30,47, D249B-12,28, D249C-16,41,24,
E249A-45,15,21, E249B-43,16,4,

LOT CERTIFICATION TEST REPORT 3B2085-XA Rev -
Ref P528/ATP-08001/B
Contract No. NAS 9-17540

2.7 SHORT CIRCUIT TEST

a) Date(s) of Test: 17 Aug-89
b) Sample Size: 13
c) Peak Current, Each Cell: See Attachment
d) Temperature Rise on Each Cell: See Attachment
e) Result of Test: ACCEPTABLE
f) Date Codes and Serial Numbers: C249B-41, C249C-41, D249A-41, 14, 29, D249B-41, D249C-6, 7, 20, E249A-1, 3, E249B-37, 13,

2.8 VIBRATION TEST

a) Date(s) of Test: 18Aug-89
b) Sample Size: 4
c) Result of Test: ACCEPTABLE Attach Report From Testing Vendor
d) Date Codes and Serial Numbers: C249B-9, D249A-42, D249C-3, E249B-27,

2.9 300°F EXPOSURE TEST

a) Date of Test: 10Aug-89
b) One Unfinished (unfused) Cell
c) Result of Test: ACCEPTABLE
d) Cell Date Code and Serial Number: D249A-4,

NASA LOT CERTIFICATION SEQUENCE

P/N 3B2085-XA CCD Rev - NASA CONTRACT NAS 9-18142

CERTIFICATION LOT # 4 DATE CODES A299A, A299B

PASSED ATP
(X-RAY, 160° OVEN, OCV, LOAD, DIAMETER, LENGTH, WEIGHT)

LOT CERTIFICATION SAMPLE
n = 21

n = 1
300° F EXPOSURE TEST
No leakage
☒ Pass ☐ Fail

n = 6
CAPACITY DISCHARGE
10 Ohm load
Ave. Ah = 25 Ah. minimum
= 30
: curves attached

n = 6
FUSE CHECK
Must blow within 15 sec. at 10 Amps.
No. Failed 0

OVERDISCHARGE STORAGE CONDITIONING
3 ± 1 Wk. @ Rm. Temp.
FORWARD @ LATER DATE ✓

n = 1
OVERDISCHARGE
Hi Current Rm. Temp. with Diode Shunt for 2 hrs at Reg. Voltage
No pass/fail criteria

n = 5
OVERDISCHARGE
Low current @ 160°F with Diode Shunt for 16 hours.
NO Vent or Rupture
No. Failed 0

n = 5
OVERDISCHARGE
Low current @ 160°F without Diode Shunt for 16 hours.
NO pass/fail criteria

n = 6
HIGH TEMP. EXPOSURE
Headers Exposed
200°F ± 10° for 2 ± 0.1 Hr.
No Vent or Leakage
No. Failed 0

n = 6
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

n = 4
SHORT CIRCUIT
No Vent or Leakage
No. Failed 0

n = 4
VIBRATION
No change in OCV
Load voltage = 3.5V min. after 90 ±10 sec.
No. Failed 0

n =
HIGH RATE DISCHARGE
1.5 Ohm load at Rm. Temp.
NO pass/fail criteria

TEST REPORT FOR CERTIFICATION LOT # 4 PART No 3B2085-XA Rev -
Contract No. NAS 9-18142

1.1 SERIALIZATION

a) Date Codes and Serial Numbers: A299A-1, 6, 11, 13, 25, 29, 38, 44, 46, A299B-1, 2, 9, 14, 19, 26, 31, 44,

1.2 X-RAYS

a) See x-rays in separate package.
b) Date of x-ray: 19 July 89

1.3 160°F EXPOSURE

a) Chart and thermocouple locations: See recorder chart attached.
b), c) and d) OCV, Load Voltage, Dimensions: See separate report 3-3115/0489.

2.1 LOT DEFINITION

a) Battery or Cell Type 3B2085-XA Rev -
b) Electrolyte Lot Number: 8919I-01
c) Date Codes: A299A, A299B
d) Pour Dates: 20 July 89

2.2 CAPACITY DISCHARGE TEST

a) Date(s) of Test: 14 July 89
b) Sample Size: 6
c) Minimum Average Capacity Requirement: 25 AH
d) Average Capacity Obtained: 30
e) Load Used: 10 OHM
f) Individual Cell Capacities: Rundown Test Curves Attached
g) Date Codes and Serial Numbers: A299A-2, 17, 27, A299B-10, 18, 28,

LOT CERTIFICATION TEST REPORT 3B2085-XA Rev -
Ref P528/ATP-08001/B
Contract No. NAS 9-17540

2.3 HIGH TEMPERATURE EXPOSURE
a) Date(s) of Test: 17 July 89
b) Sample Size: 6
c) Test Results: ACCEPTABLE
d) Date Codes and Serial Numbers: A299A-30, 37, 45, A299B-4, 33, 39

2.4 HIGH RATE DISCHARGE
a) Date(s) of Test: 17 July 89
b) Sample Size: 6
c) Average Capacity Obtained: 26 AH
d) Load Used: 1.5
e) Individual Cell Capacities: Rundown Test Curves Attached
f) Date Codes and Serial Numbers: A299A-30, 37, 45 A299B-4, 33, 39,

2.5 FUSE CHECK TEST
a) Date(s) of Test: 22 Aug. 89
b) Sample Size: 6
c) Result of Test: ACCEPTABLE
d) Date Codes and Serial Numbers: A299A-2, 17, 27, A299B-10, 18, 28,

2.6 OVERDISCHARGE TEST – FORWARD @ LATER DATE ✓
a) Date(s) of Test: 14 SEPT 89
b) Sample Size: 6
c) Result of RT Test: ACCEPTABLE
d) Result of 160°F Test With Diodes: ACCEPTABLE
e) Result of 160°F Test Without Diodes: NO PHYSICAL CHANGE
f) Date Codes and Serial Numbers: A299B-18 / A299B-28, 10, A299A-2, 17, 27,

LOT CERTIFICATION TEST REPORT 38208S-XA Rev -
Ref P528/ATP-08001/B
Contract No. NAS 9-17540

2.7 SHORT CIRCUIT TEST

a) Date(s) of Test: 17 Aug. 89
b) Sample Size: 4
c) Peak Current, Each Cell: See Attachment
d) Temperature Rise on Each Cell: See Attachment
e) Result of Test: ACCEPTABLE
f) Date Codes and Serial Numbers: A299A-15, 40, A299B-8, 27,

2.8 VIBRATION TEST

a) Date(s) of Test: 18 Aug 89
b) Sample Size: 4
c) Result of Test: ACCEPTABLE Attach Report From Testing Vendor
d) Date Codes and Serial Numbers: A299A-24, 33, A299B-30, 45,

2.9 300°F EXPOSURE TEST

a) Date of Test: 10 Aug. 89
b) One Unfinished (unfused) Cell
c) Result of Test: ACCEPTABLE
d) Cell Date Code and Serial Number: A299A-36,

BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

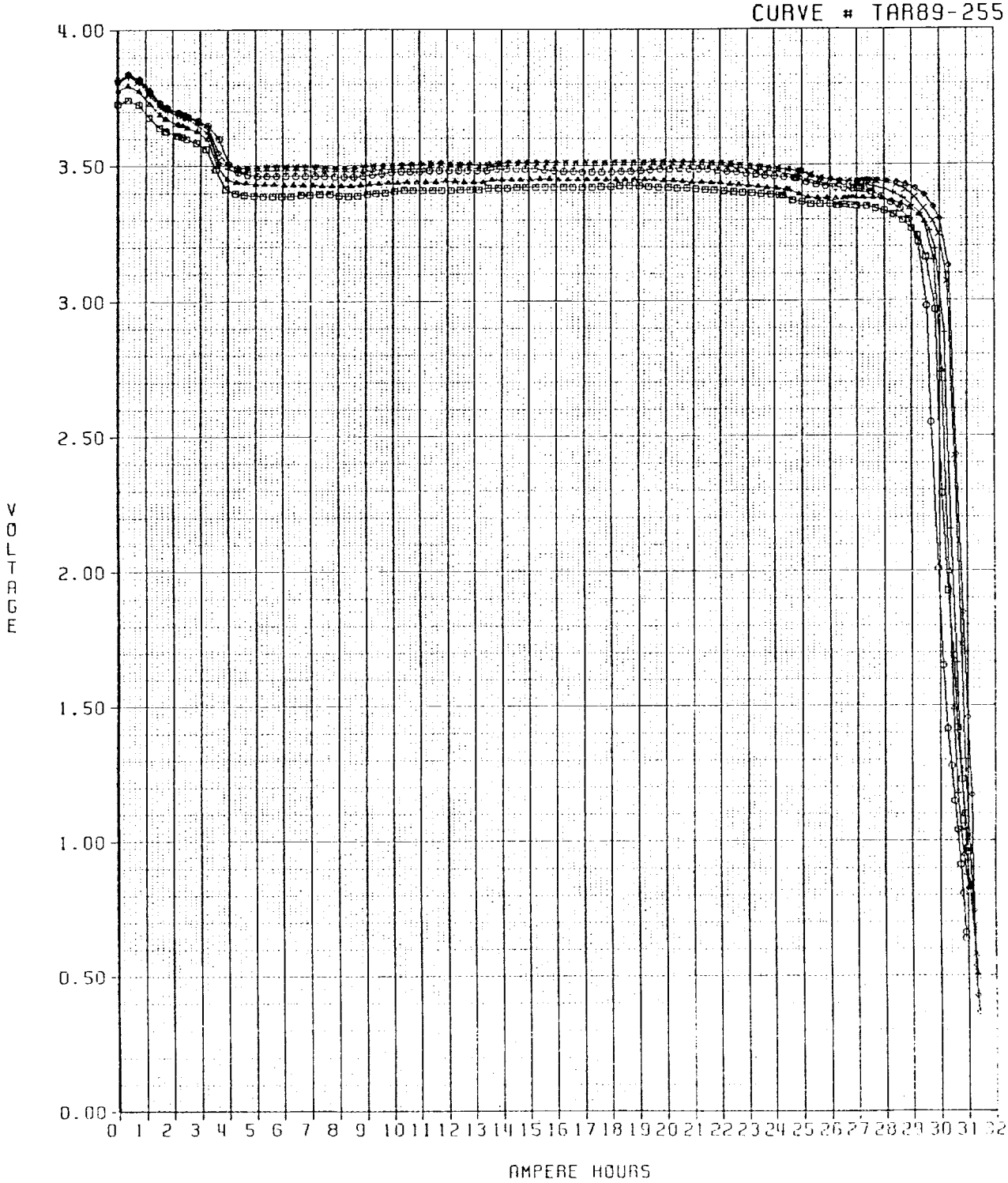
S/N 18059 □ A249A
S/N 18060 ⏀ A249A
S/N 18061 △ A249A
S/N 18062 + A249B
S/N 18063 × A249B
S/N 18064 ◇ A249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

STRIBUTION: P. KREHL B. WEBSTER S. EBEL A. SAMIT
O. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255



BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

S/N 18065 □ B249A
S/N 18066 ⏀ B249A
S/N 18067 △ B249A
S/N 18068 + B249B
S/N 18069 × B249B
S/N 18070 ◇ B249B

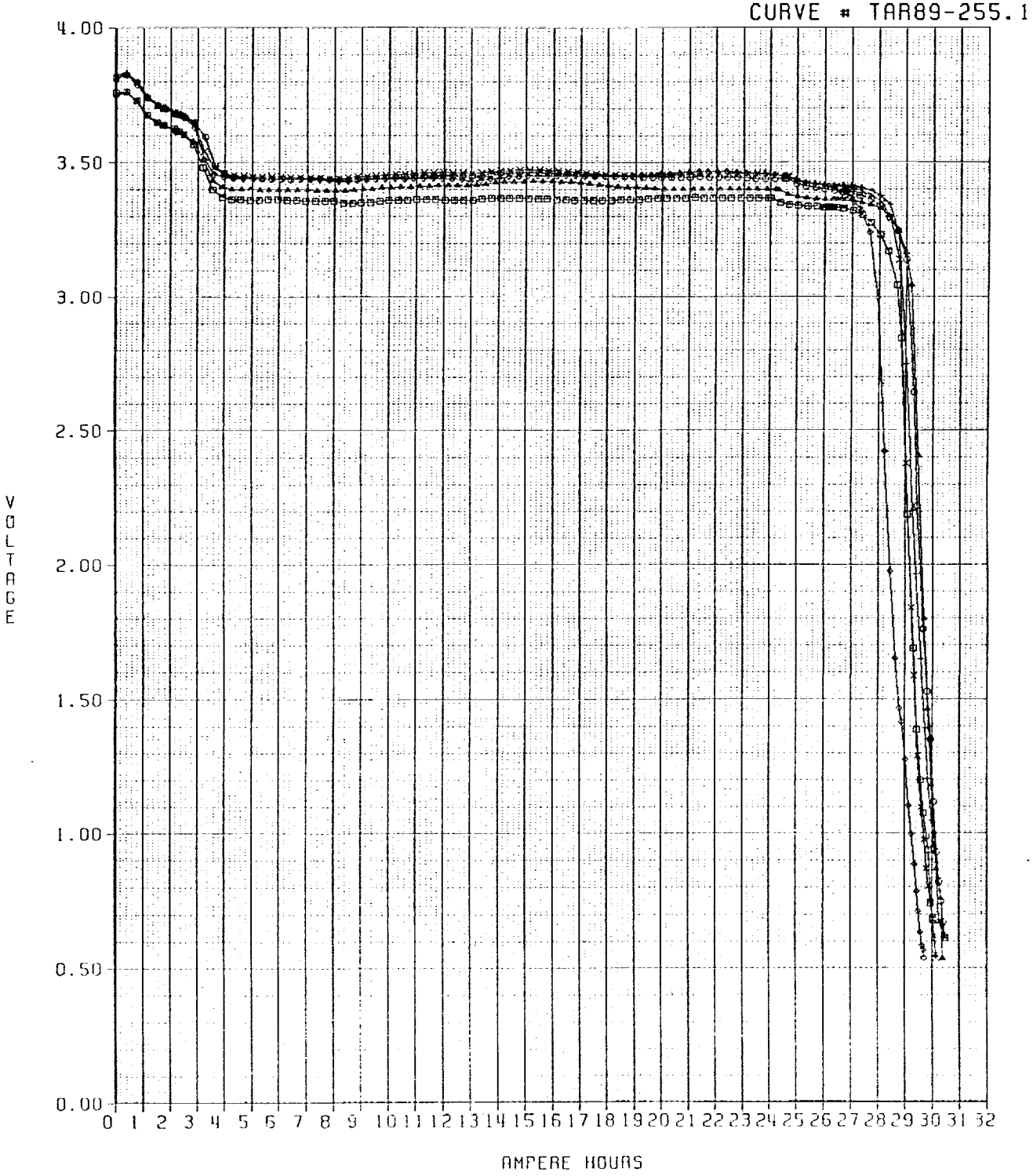
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION:

P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255.1



GPLOT(REV. 3.1)

DAY 199 TUE, JUL 18 1989 1:53:55 PM

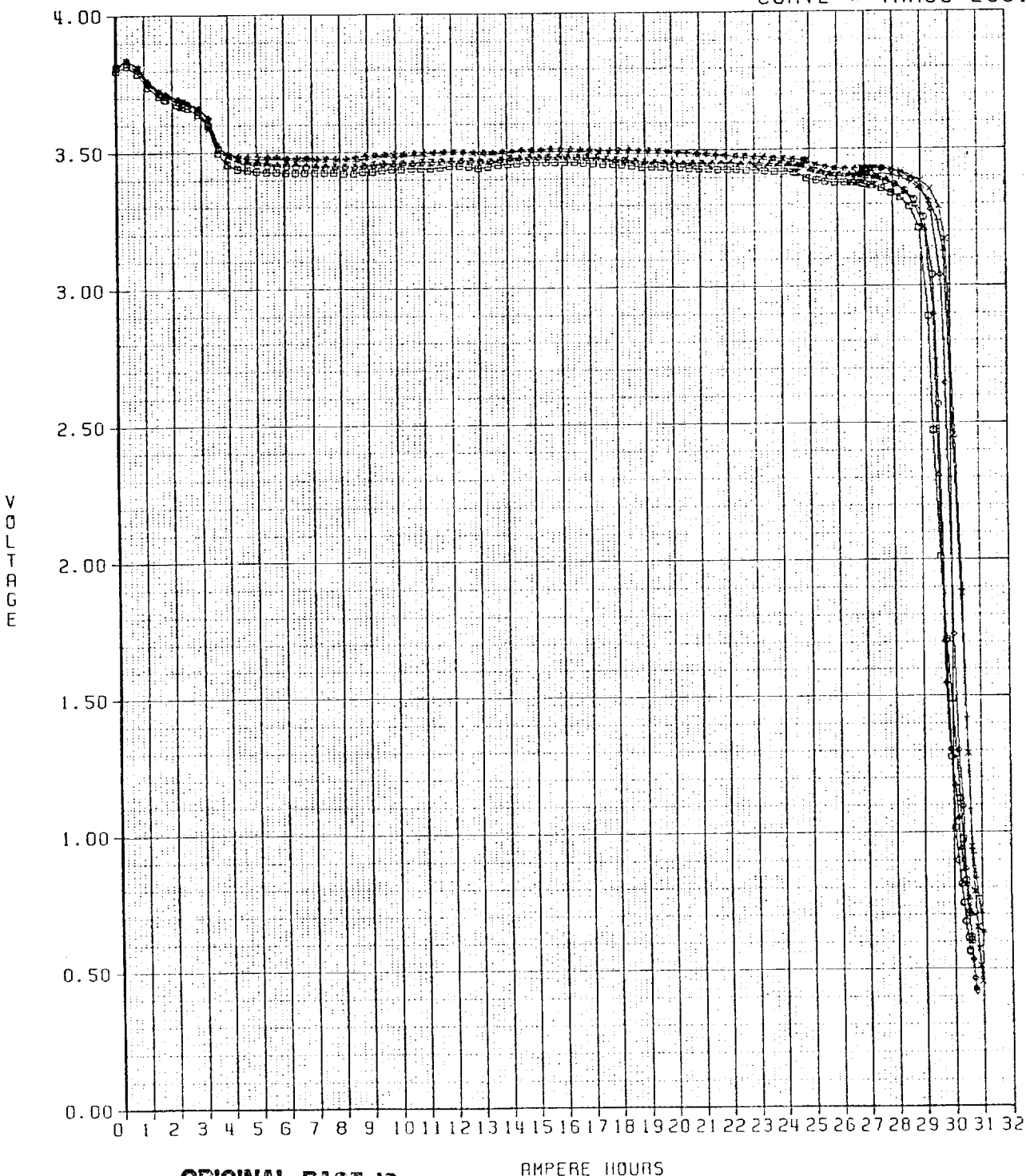
BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

S/N 18071 □ B249C
S/N 18072 ◯ B249C
S/N 18073 △ B249C
S/N 18074 + C249B
S/N 18075 × C249B
S/N 18076 ◇ C249B
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255.2



BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

S/N 18077 □ C249C
S/N 18078 ⏀ C249C
S/N 18079 △ C249C
S/N 18080 + D249A
S/N 18081 × D249A
S/N 18082 ◇ D249A

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255.3

ORIGINAL PAGE IS
OF POOR QUALITY

GPLOT(REV. 3.1)

DAY 199 TUE. JUL 18 1989 2:56:20 PM

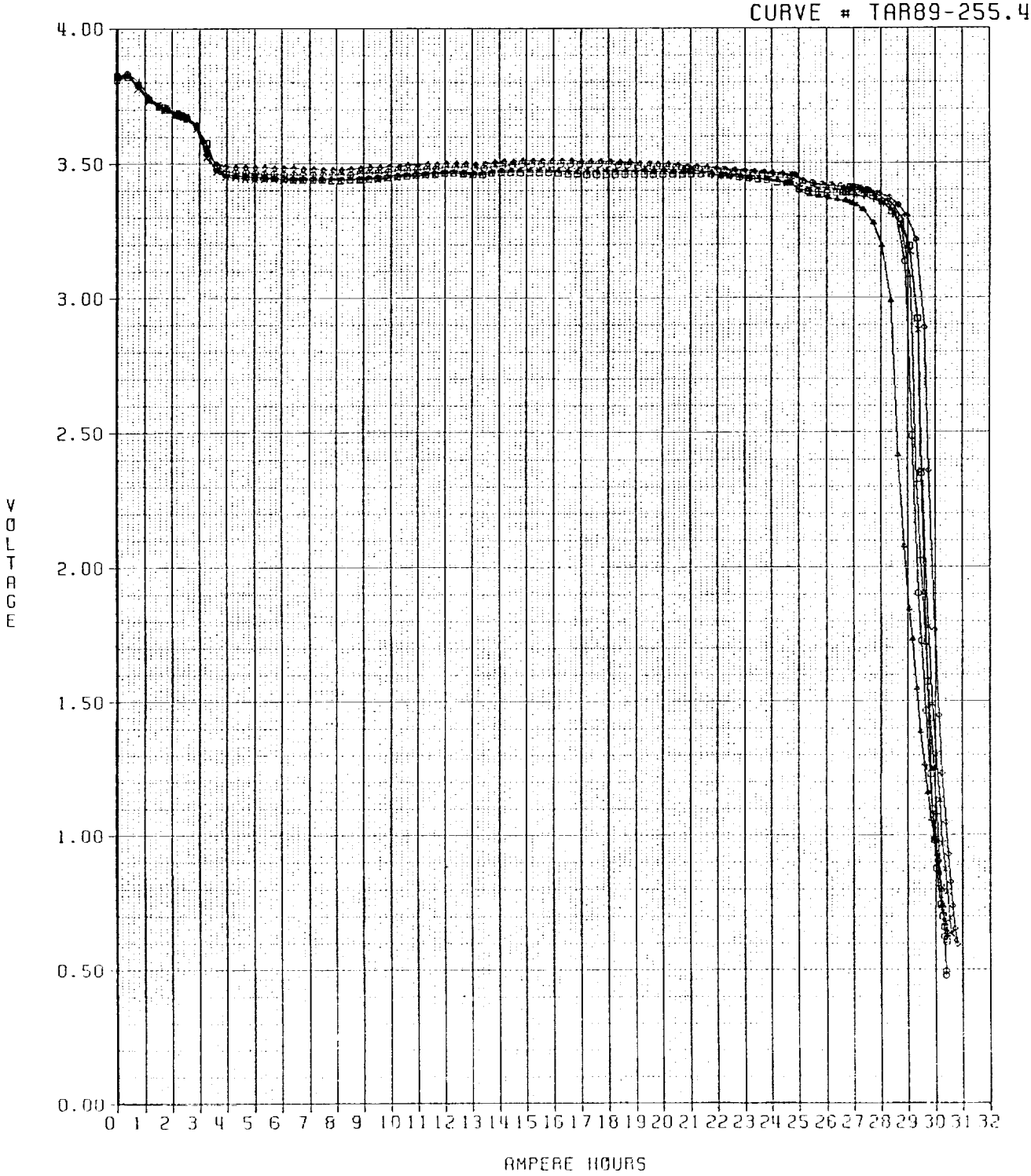
BCX 149DD - · 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

S/N 18083 □ D249B
S/N 18084 ⓘ D249B
S/N 18085 △ D249C
S/N 18086 + D249C
S/N 18087 × D249C
S/N 18088 ◇ E249A
DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION:
P. KAEHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255.4



GPLOT(REV. 9.1)

DAY 200 WED. JUL 19 1989 09:25:22 AM

BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

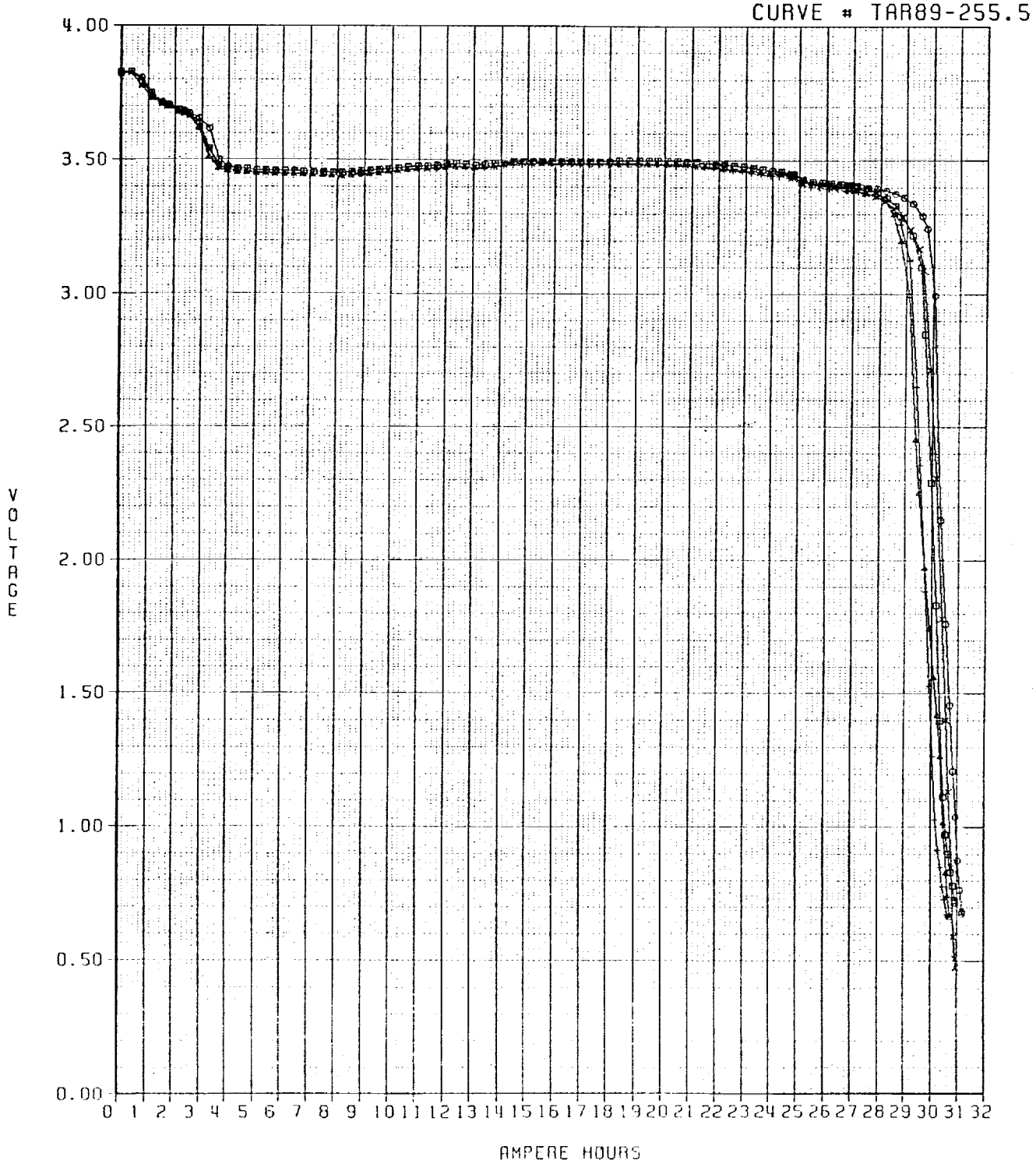
S/N 18089 □ E249A
S/N 18090 ⏀ E249A
S/N 18091 △ E249B
S/N 18092 + E249B
S/N 18093 × E249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KREHL, B. WEBSTER, S. EBEL, R. SAMIT, D. SIEMINSKI, R. STINEBRING, R. NEUMANN

WG

ON TEST 14JUL89
CURVE # TAR89-255.5



BCX 1490D - 3B2085-XA
NASA LOT CERTIFICATION
CAPACITY DISCHARGE

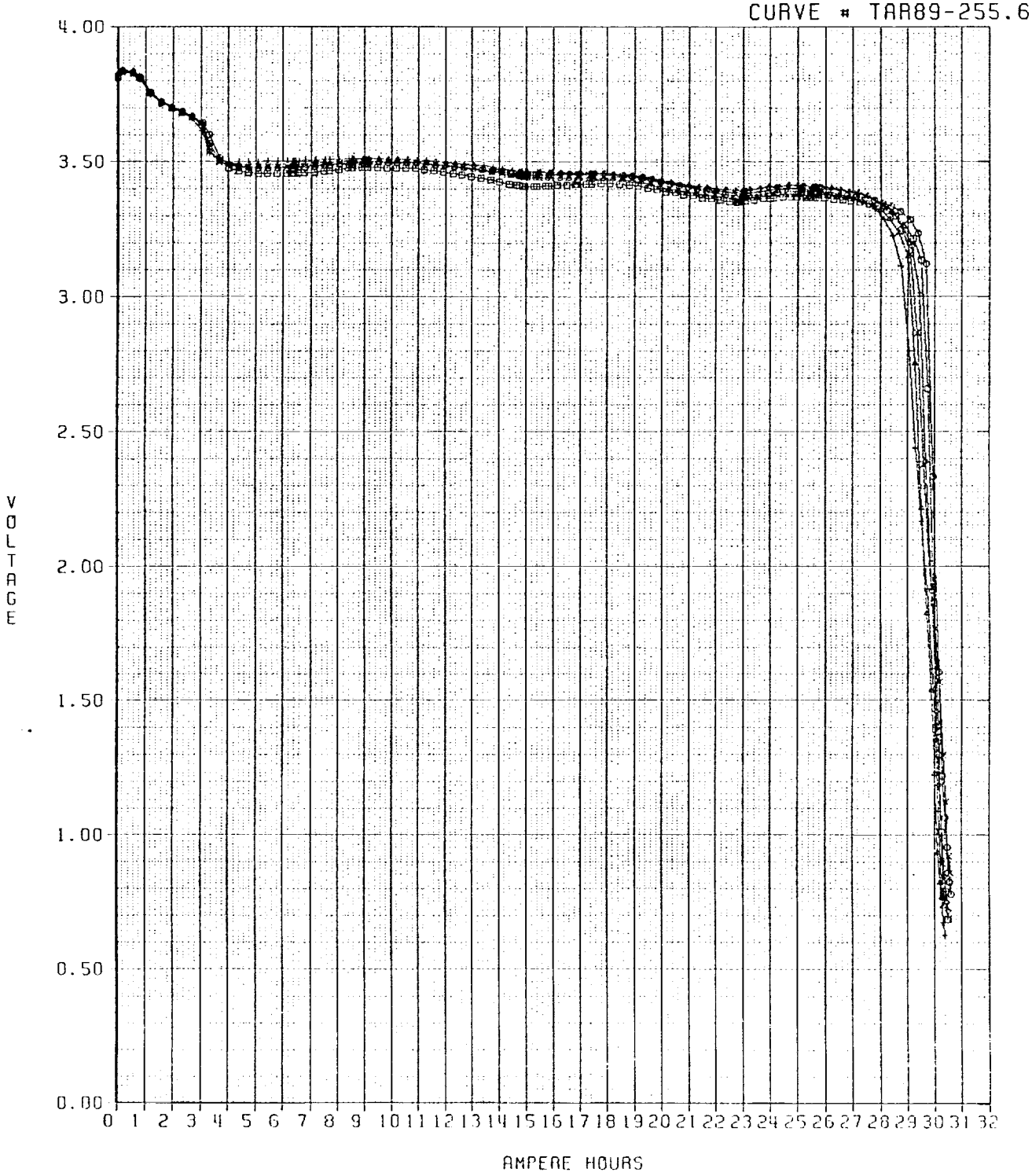
S/N 18094 ⊡ A299A
S/N 18095 ⊙ A299A
S/N 18096 △ A299A
S/N 18097 + A299B
S/N 18098 × A299B
S/N 18099 ◇ A299B

DISCHARGED AT ROOM TEMPERATURE UNDER A 10 OHM LOAD

DISTRIBUTION: P. KRAHL B. WEBSTER S. EBEL R. SAMIT D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 15AUG89
CURVE # TAR89-255.6



GPLOT(REV. 3.1)

DAY 231 SAT. AUG 19 1989 11:37:52 AM

BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
VIBRATION EXPOSURE

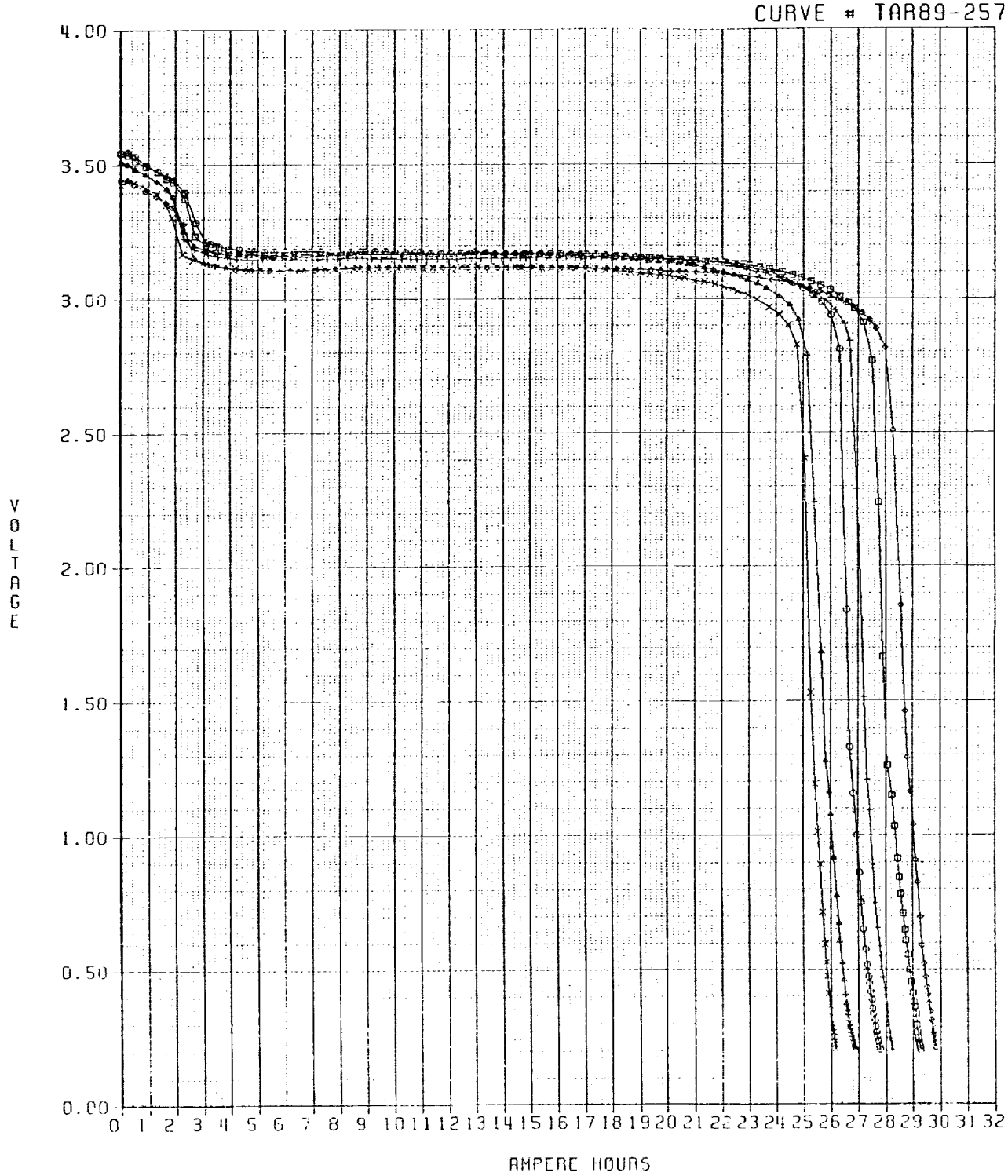
S/N 18141 □ A249A
S/N 18142 ⏀ A249A
S/N 18143 △ B249A
S/N 18144 + B249B
S/N 18145 × B249B
S/N 18146 ◇ B249C

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KAEHL, B. WEBSTER, S. EBEL, R. SAMIT, D. STEMINSKI, R. STINEBRING, R. NEUMANN

WG

ON TEST 21AUG89
CURVE # TAR89-257



BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
VIBRATION EXPOSURE

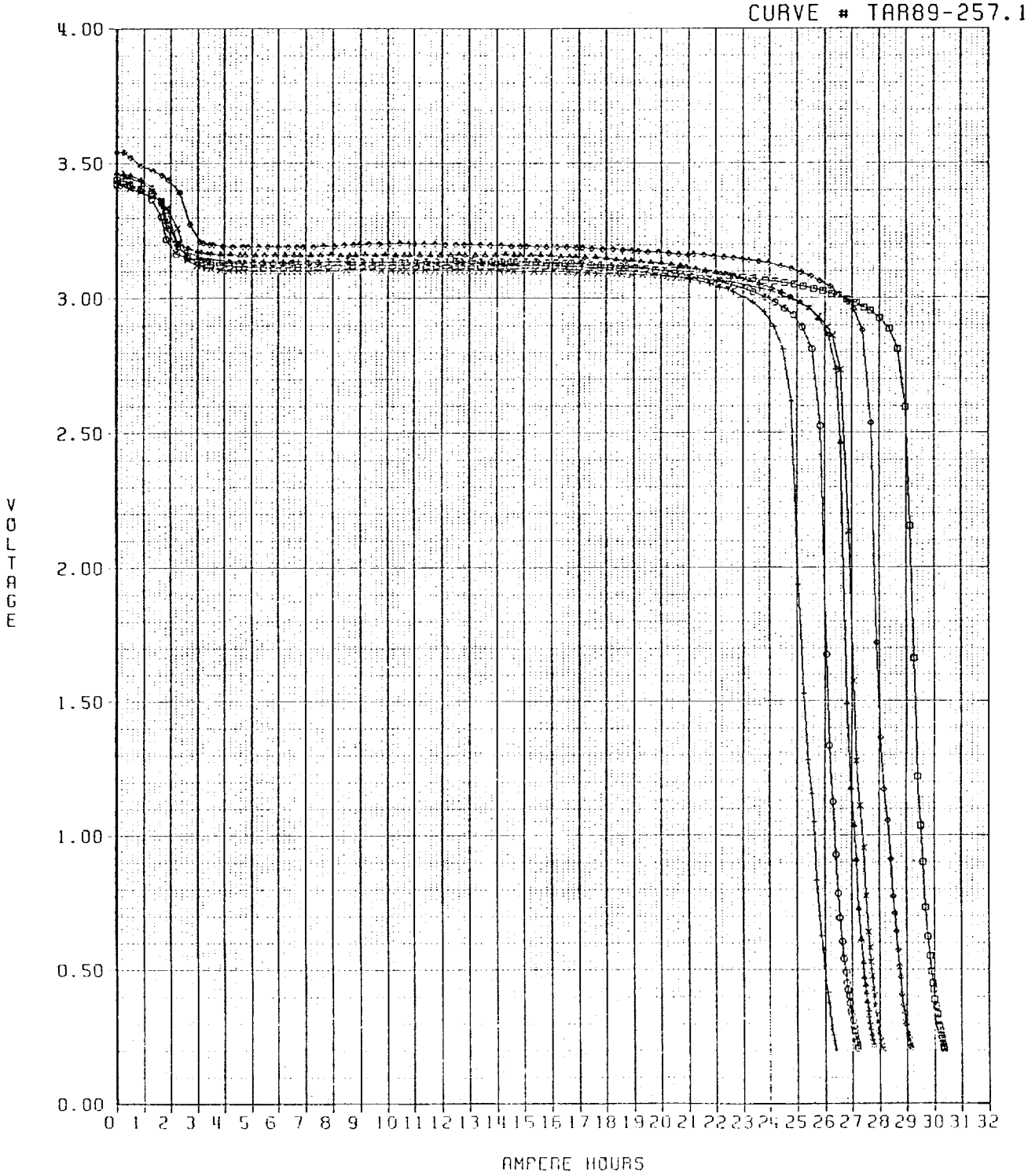
S/N 18147	□ C249B	S/N 18148	⊙ D249A
S/N 18149	△ D249C	S/N 18150	+ E249B
S/N 18151	× A249B	S/N 18152	◇ A249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KAEHL, B. WEBSTER, S. EBEL, R. SAMIT, D. SIEMINSKI, R. STINEBRING, R. NEUMANN

WG

ON TEST 21AUG89
CURVE # TAR89-257.1



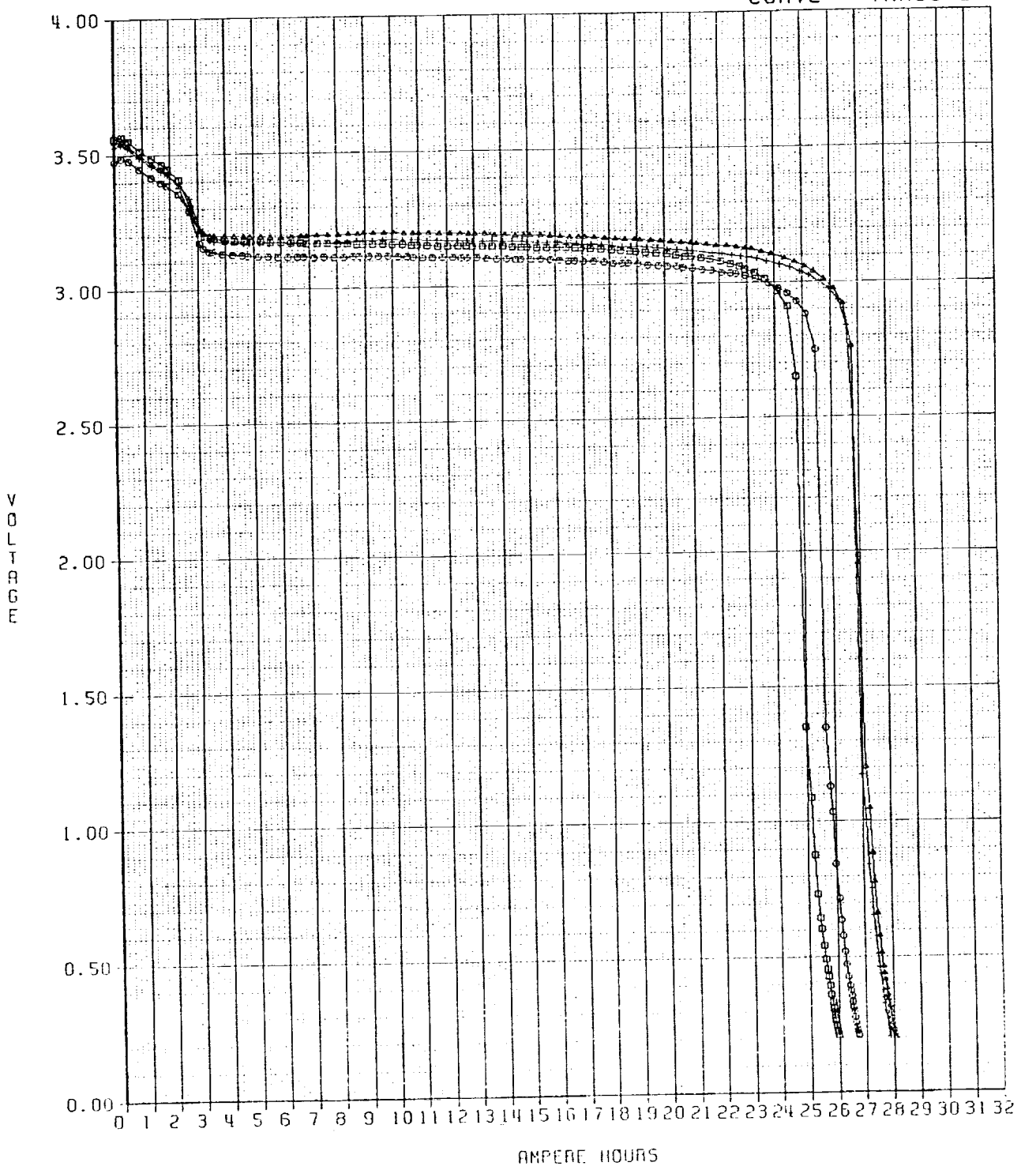
BCX 149DD - 3B2085-XA
NASA LOT CERTIFICATION
VIBRATION EXPOSURE

S/N 18153 □ A299A
S/N 18155 △ A299B
S/N 18154 ⏀ A299A
S/N 18156 + A299B

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL, B. WEBSTER, S. EBEL, R. SAMIT, D. SIEMINSKI, R. STINEBRING, R. NEUMANN

ON TEST 21AUG89
CURVE # TAR89-257.2



GPLOT(REV. 3.1)

DAY 234 TUE, AUG 22 1989 1:00:48 PM

BCX 14900.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

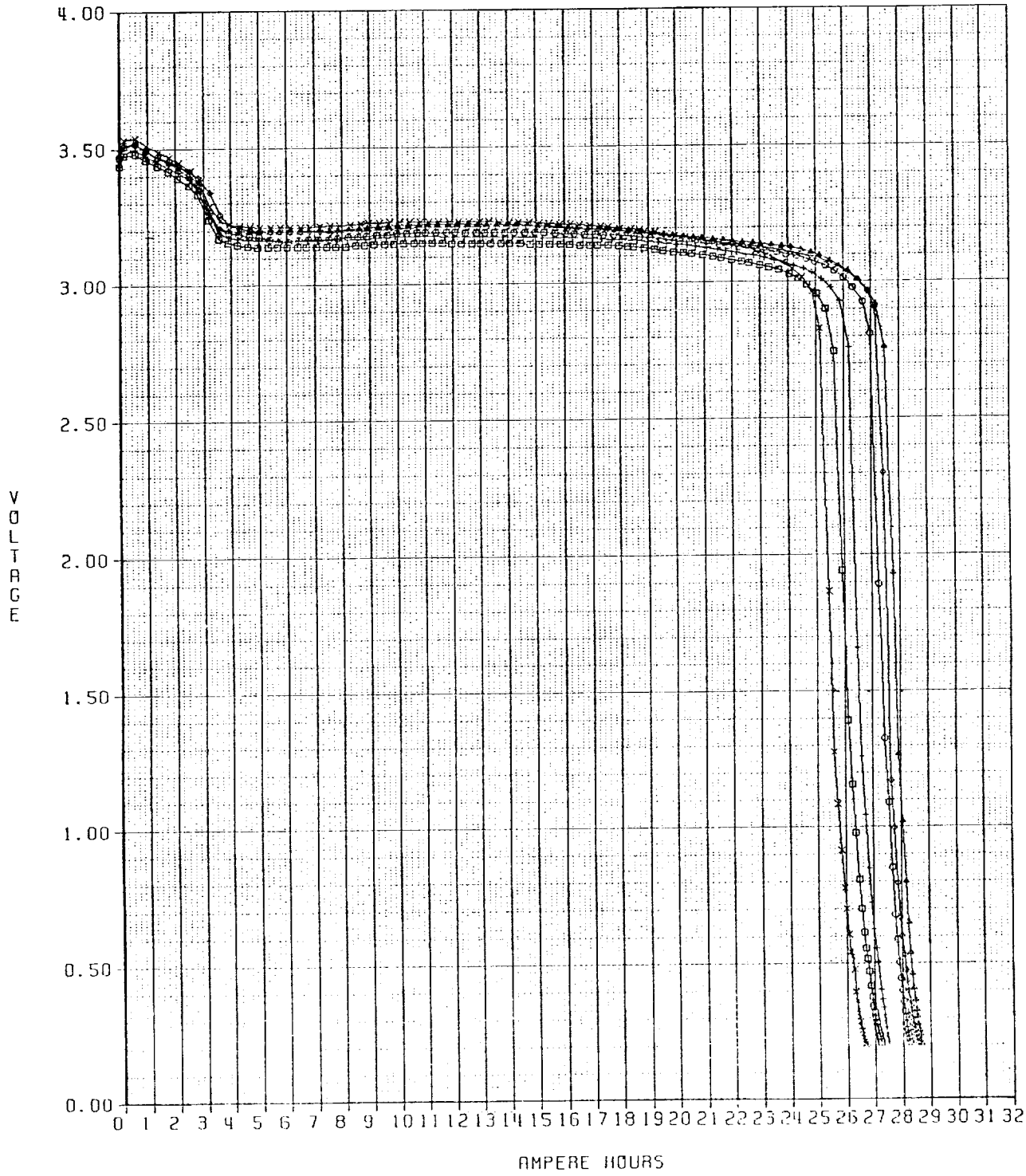
S/N 18100 □ A249A
S/N 18101 ⏀ A249A
S/N 18102 △ A249A
S/N 18103 + A249B
S/N 18104 × A249B
S/N 18105 ◇ A249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 17JUL89
CURVE # TAR89-256



BCX 1490D.HT - 382085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

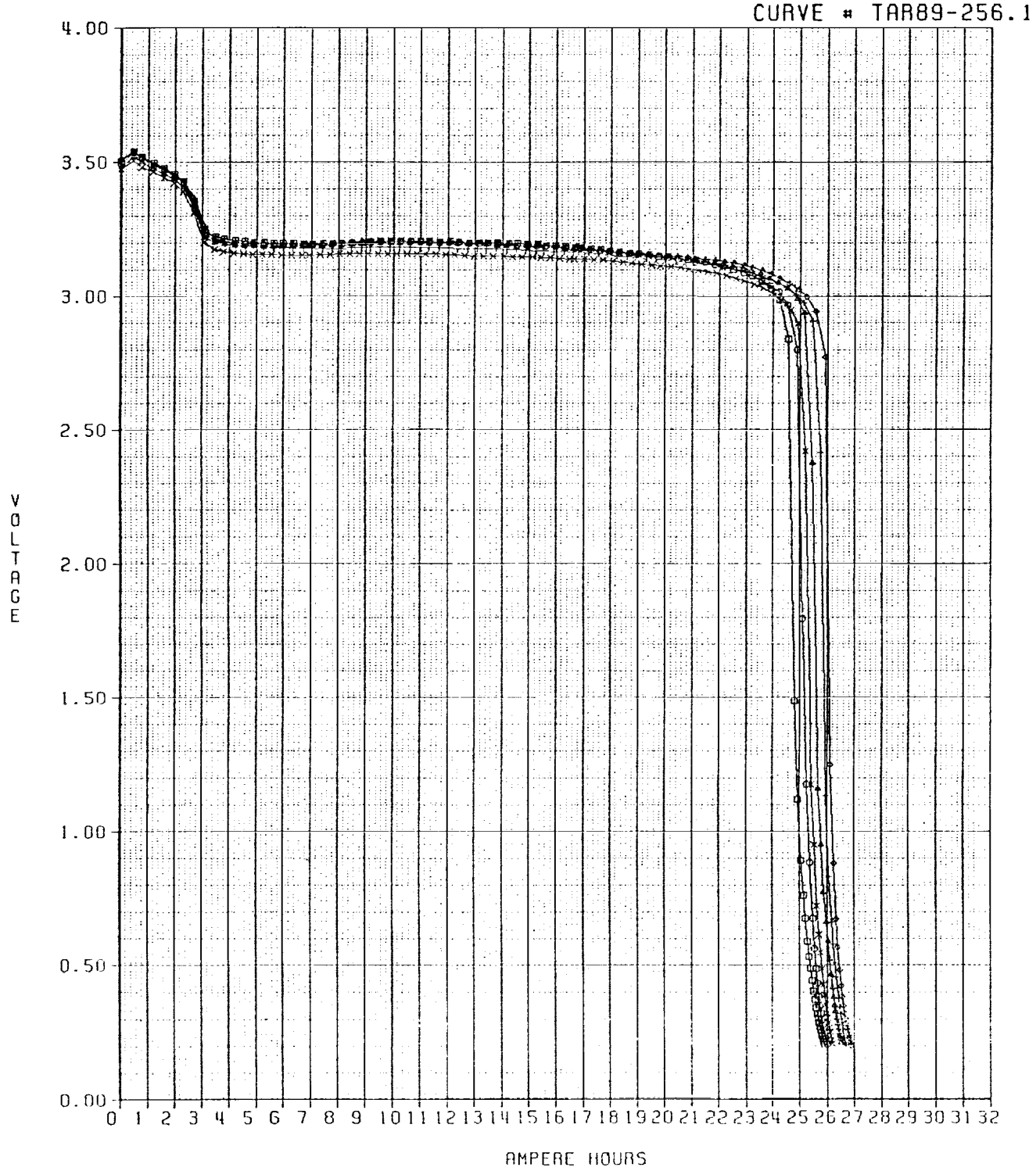
S/N 18106	□ B249A	S/N 18107	⏀ B249A
S/N 18108	△ B249A	S/N 18109	+ B249B
S/N 18110	× B249B	S/N 18111	◇ B249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 17JUL89
CURVE # TAR89-256.1



GPLOT(REV. 3.1)

DAY 199 TUE. JUL 18 1989 2:39:10 PM

BCX 149DD.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

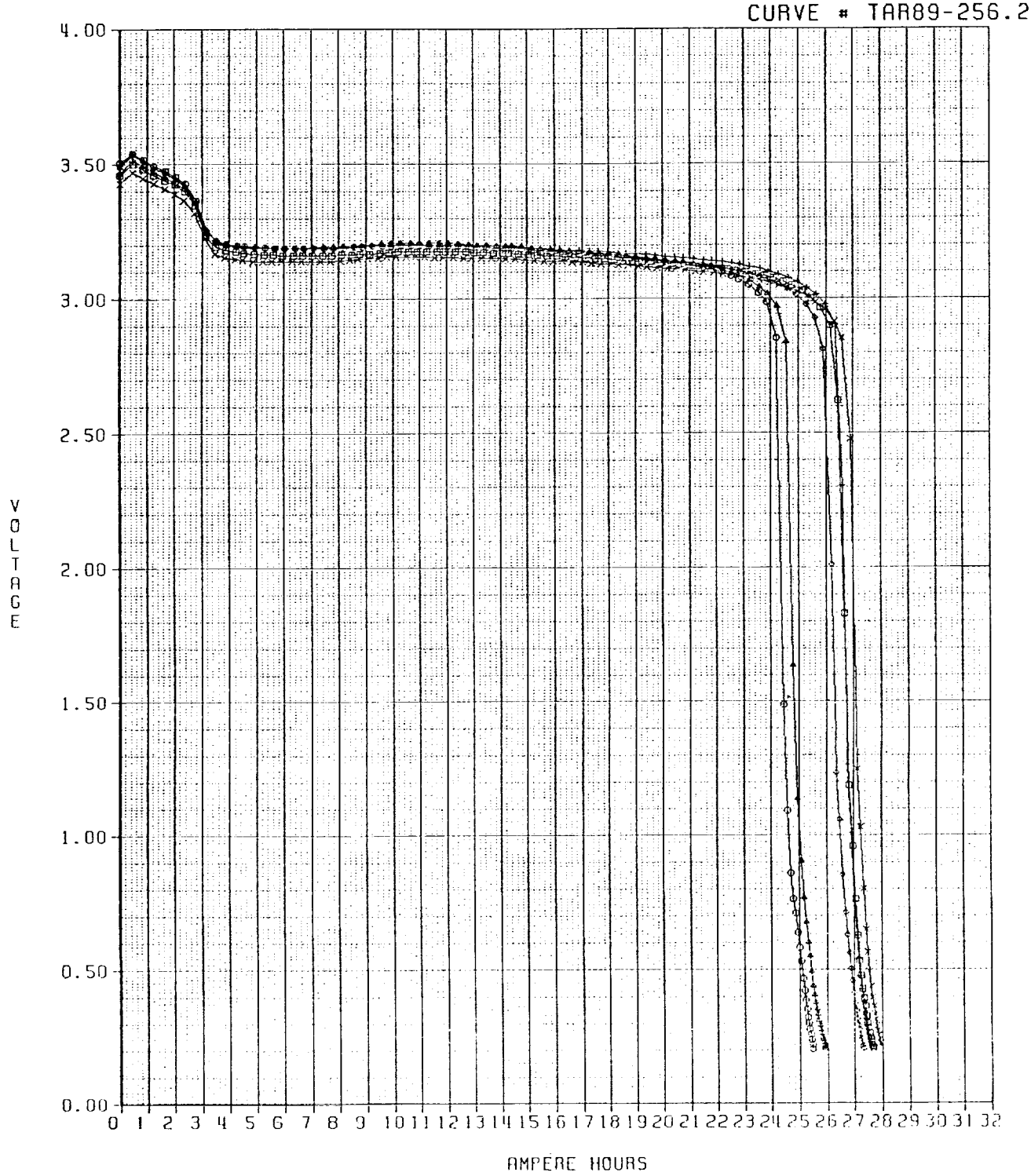
S/N 18112 □ B249C
S/N 18113 ⊙ B249C
S/N 18114 △ B249C
S/N 18115 + C249B
S/N 18116 × C249B
S/N 18117 ◇ C249B

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 17JUL89
CURVE # TAR89-256.2



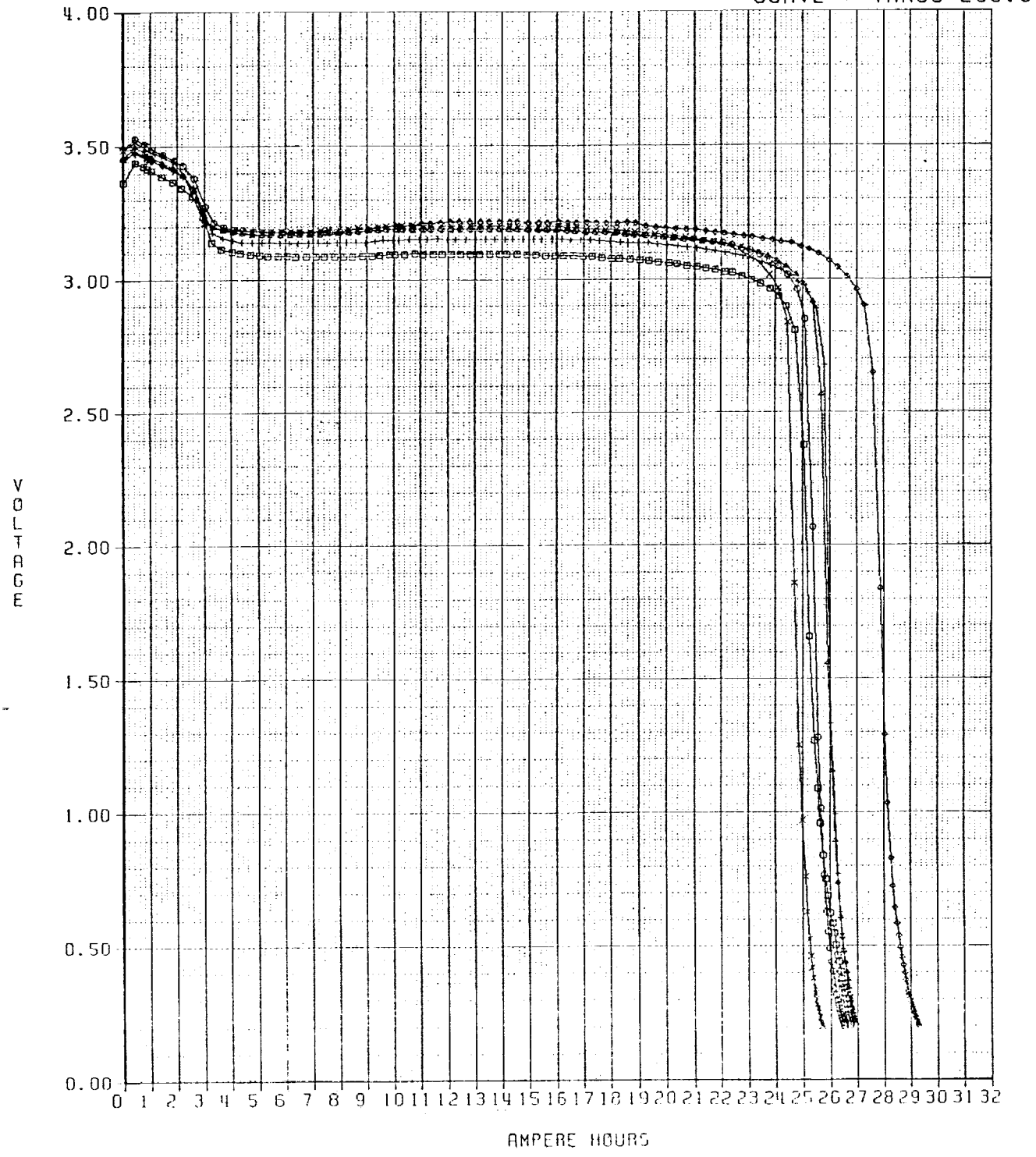
BCX 149DD.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

S/N 18118 □ C249C
S/N 18119 ⓘ C249C
S/N 18120 △ C249C
S/N 18121 + D249A
S/N 18122 × D249A
S/N 18123 ◇ D249A
DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 18JUL89
CURVE # TAR89-256.3



GPLOT (REV. 3.1)

DAY 200 WED, JUL 19 1989 11:45:51 AM

BCX 1490D.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

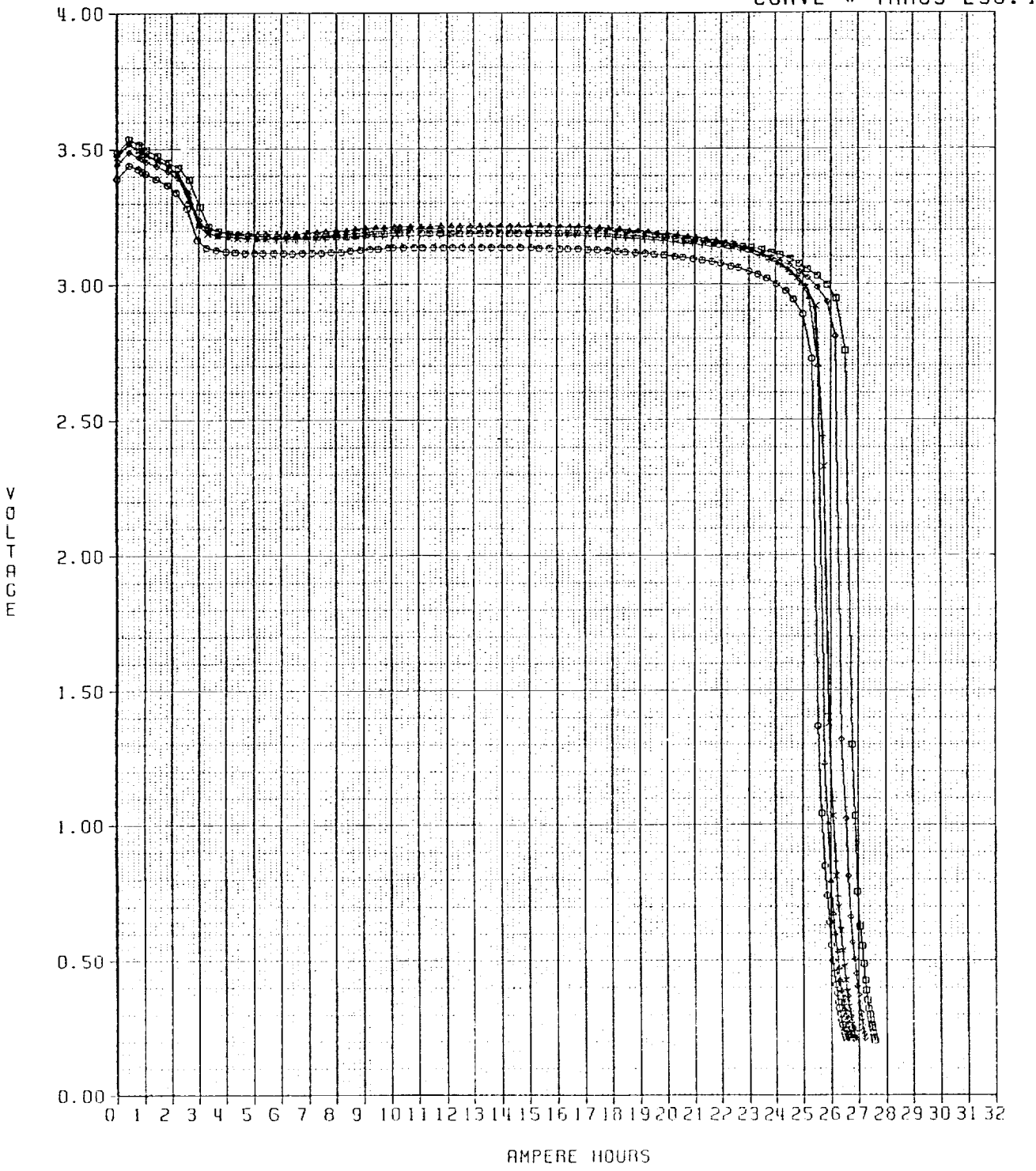
S/N 18124 □ D249B
S/N 18125 ⏀ D249B
S/N 18126 △ D249C
S/N 18127 + D249C
S/N 18128 × D249C
S/N 18129 ◇ E249A

DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

[STRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 18JUL89
CURVE # TAR89-256.4



PLOT(REV. 3.1)

DAY 200 WED, JUL 19 1989 11:52:47 AM

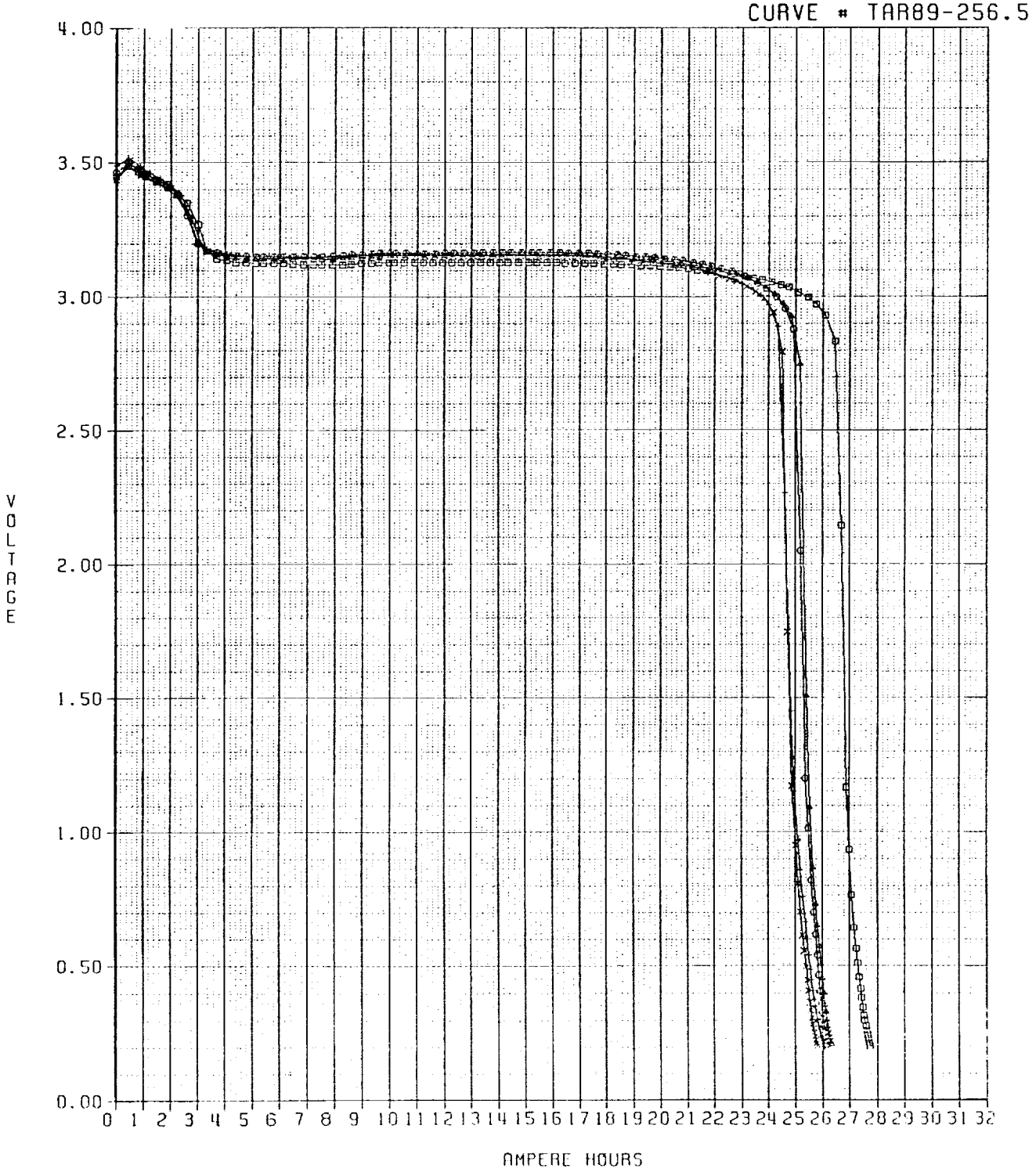
BCX 149DD.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

S/N 18130 □ E249A
S/N 18131 ⊙ E249A
S/N 18132 △ E249B
S/N 18133A + E249B
S/N 18134 × E249B
DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KAEHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING R. NEUMANN

WG

ON TEST 18JUL89
CURVE # TAR89-256.5



GPLOT(REV. 3.1)

DAY 200 WED, JUL 19 1989 11:58:09 AM

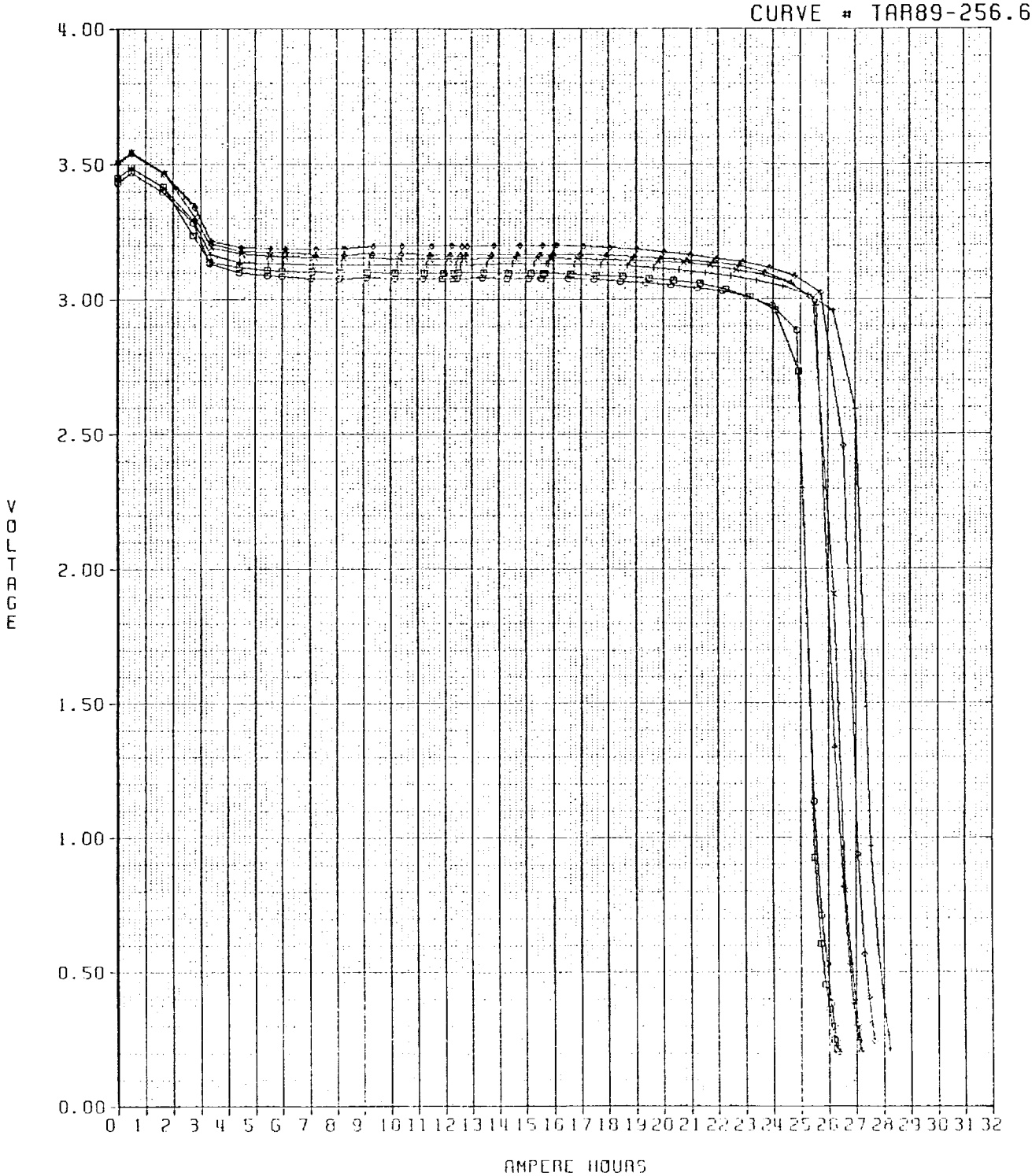
BCX 1490D.HT - 3B2085-XA
NASA LOT CERTIFICATION
HIGH TEMPERATURE EXPOSURE

S/N 18135A □ A299A
S/N 18136 ⓘ A299A
S/N 18137 △ A299A
S/N 18138 + A299B
S/N 18139 × A299B
S/N 18140 ◇ A299B
DISCHARGED AT ROOM TEMPERATURE UNDER A 1.5 OHM LOAD

DISTRIBUTION: P. KREHL B. WEBSTER S. EBEL R. SAMIT
D. SIEMINSKI R. STINEBRING B. NEUMANN

WG

ON TEST 18JUL89
CURVE # TAR89-256.6



TEST SUMMARY DATA

TEST CONDUCTED:	Random Vibration
TEST CONDUCTED FOR:	Wilson Greatbatch, Ltd.
CLIENT'S ORDER NO.:	23217
MGA FILE NO.:	C89E-02.16
TEST SPECIFICATIONS:	Random Vibration Testing per document CP-5-83-025 Rev. B
TEST SPECIMEN DATA:	Sixteen (16) BCX149 "DD" cells, P/N: 3B2085-XA S/N's" 32,41,17,B249B/3,25, 24, 9, 42,D249C/3, 27, 46, 22, 24, 33, 30, 45
DATE TEST COMPLETED:	August 18, 1989
TEST RESULTS:	No physical damage occurred to the cells as a result of the random vibration test.

1.0 RANDOM VIBRATION TESTING

The random vibration test was conducted in accordance with the following power spectral density:

Frequency (Hz.)	Acceleration (G^2/Hz.)
20 to 80	+3 db/Octave
80 to 350	0.1
350 to 2000	-3 db/Octave

The cells were random vibrated using the above power spectral density profile in each of the three (3) perpendicular axes for a duration of 15 minutes per axis.

2.0 TEST RESULTS

No physical damage occurred to the test items as a result of the random vibration test. Please refer to Appendix A of this test report for test data sheets.

3.0 TEST EQUIPMENT LIST

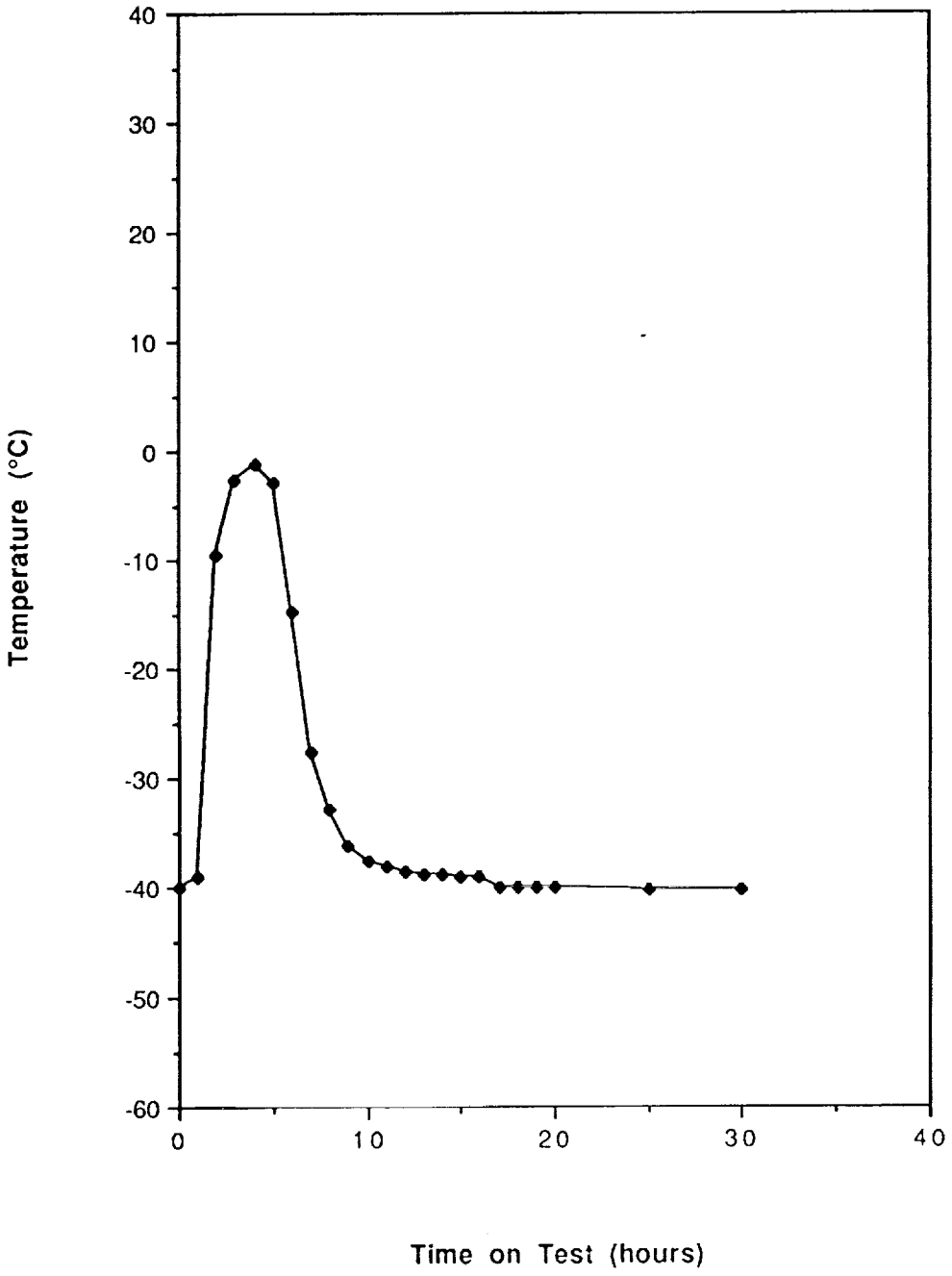
Name	Mfg.	Model	Serial No.	Cal. Date	Cal Due Date
Vibration System	U/D	SD11	-	2/27/89	8/27/89
Plotter	Primeline	RW11t	7181453.3	*	
Sweep Generator	Trig Tek	701LM	424	2/27/89	8/27/89
Analyzer	Trig Tek	7501A	132	2/27/89	8/27/89
Vibration Prot. Monitor	Trig Tek	620B	104	2/27/89	8/27/89
Compressor	Trig Tek	801B	399	2/27/89	8/27/89
Multi Level Programmer	Trig Tek	831A	185	2/27/89	8/27/89

* Calibrated before each use.

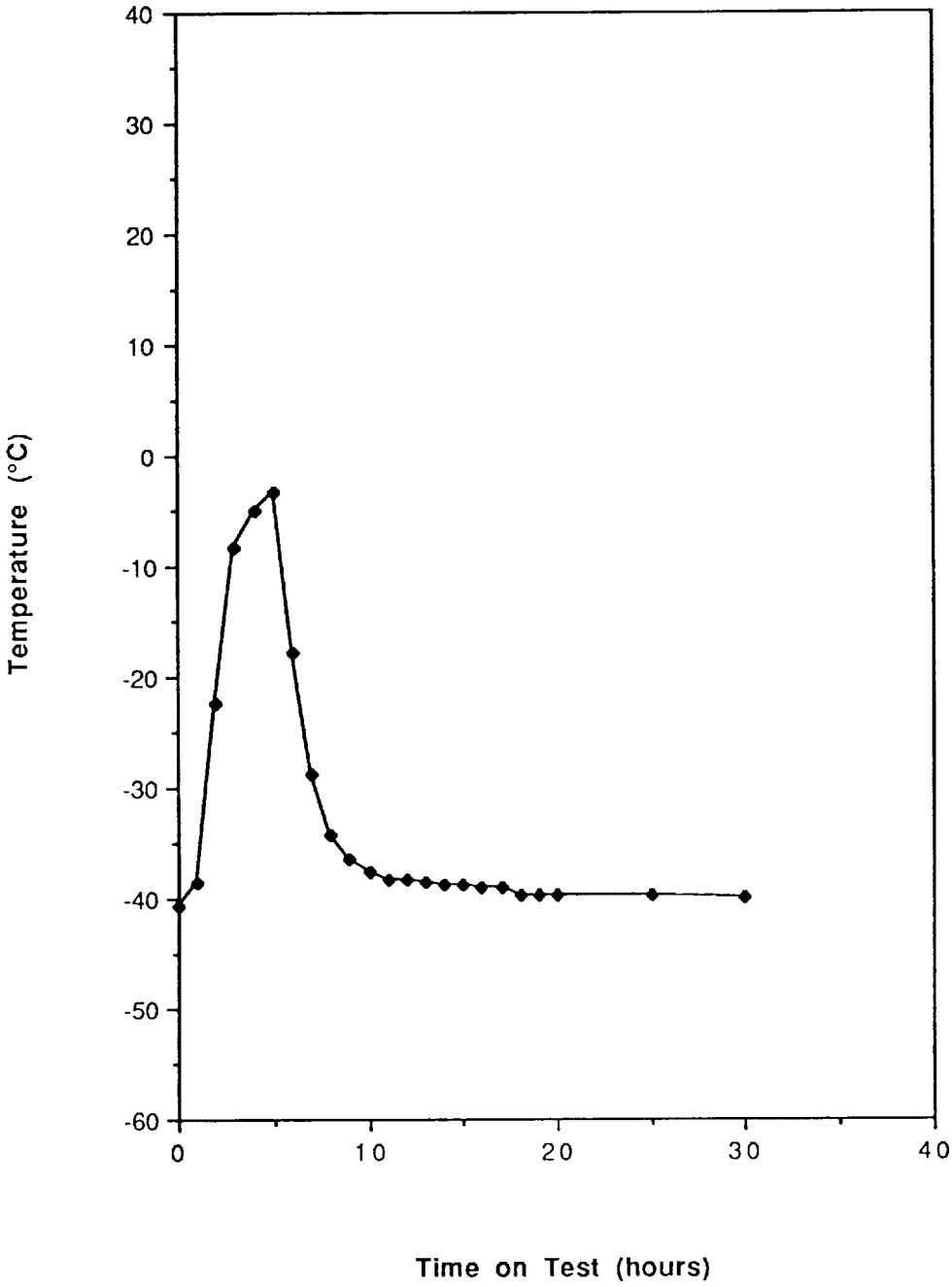
Appendix C

Temperature versus Time Graphs for Capacity Performance Test Cells

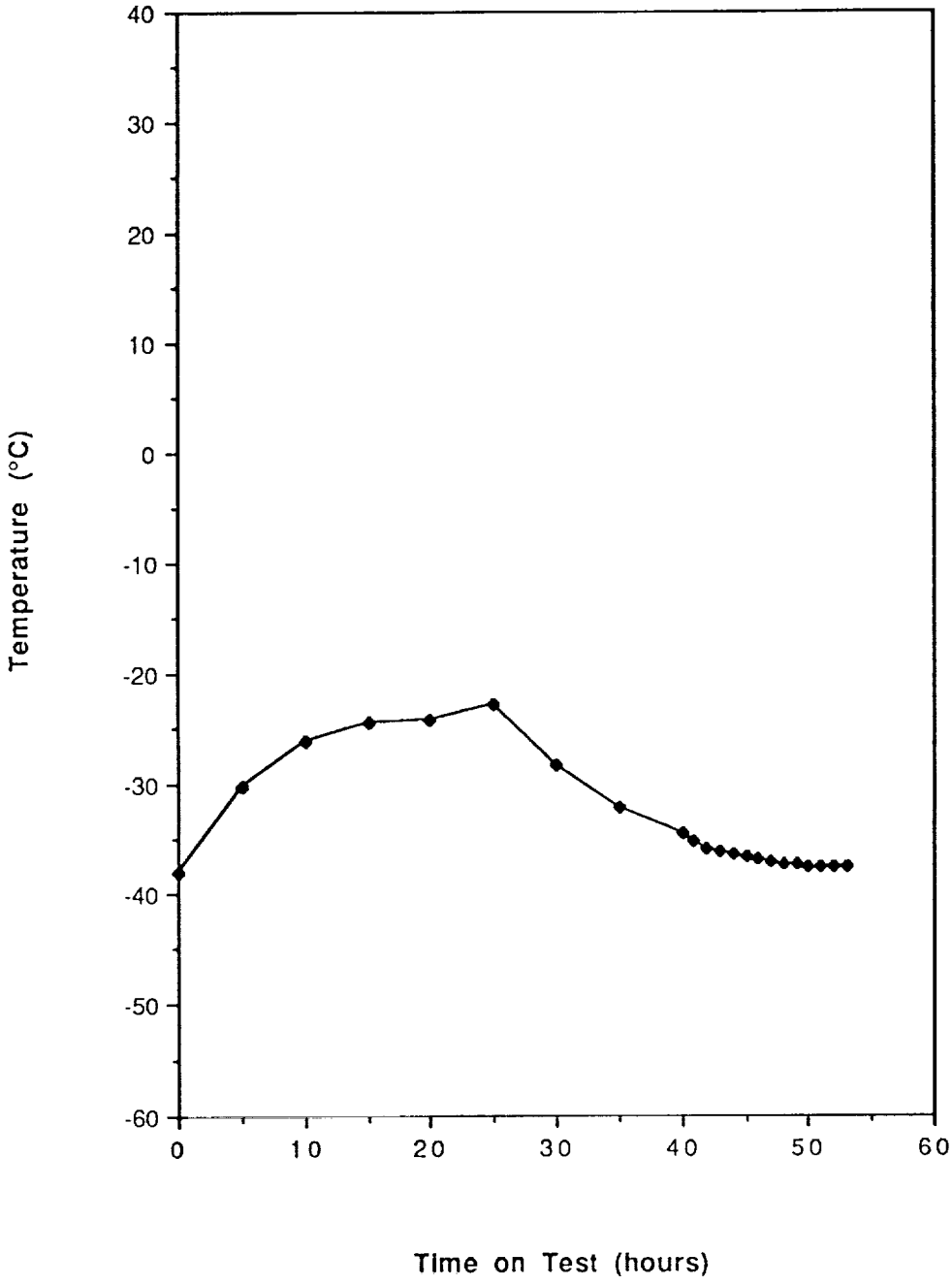
Temperature vs. Time on Test
SN 18230 - 1Ω/-40°C



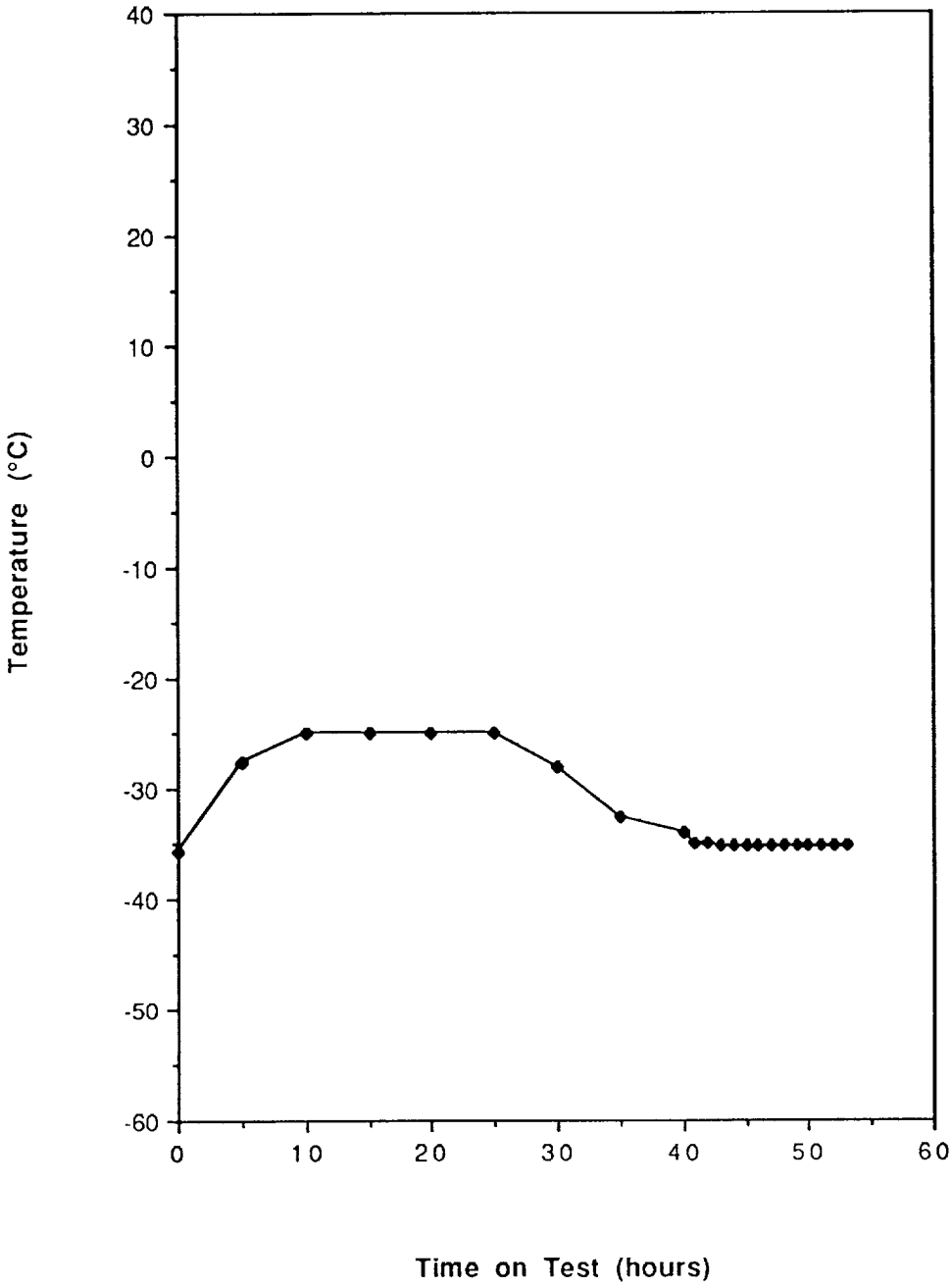
Temperature vs. Time on Test
SN 18310 - 1Ω/-40°C



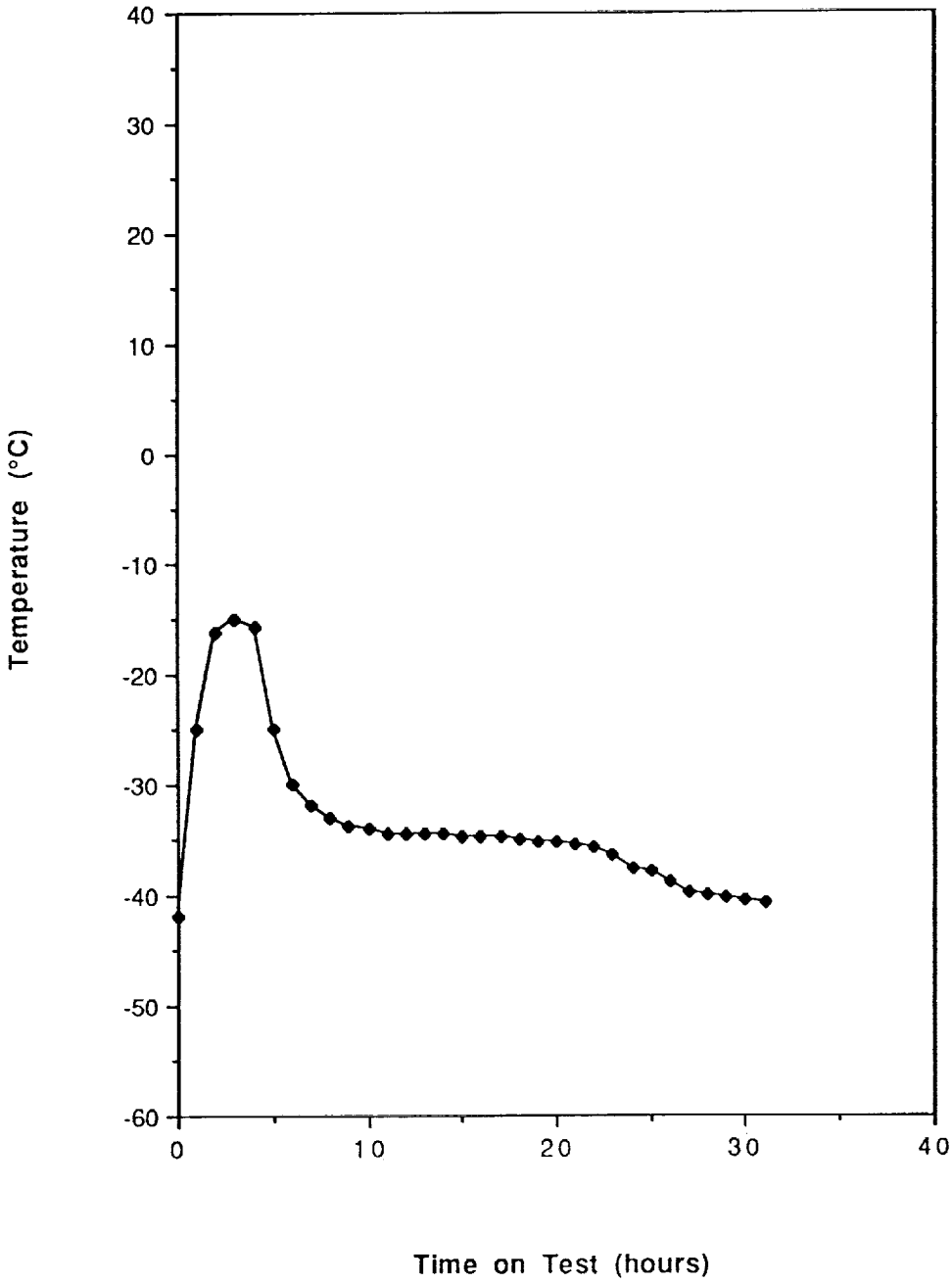
Temperature vs. Time on Test
SN 18268 - 1.5Ω/-40°C



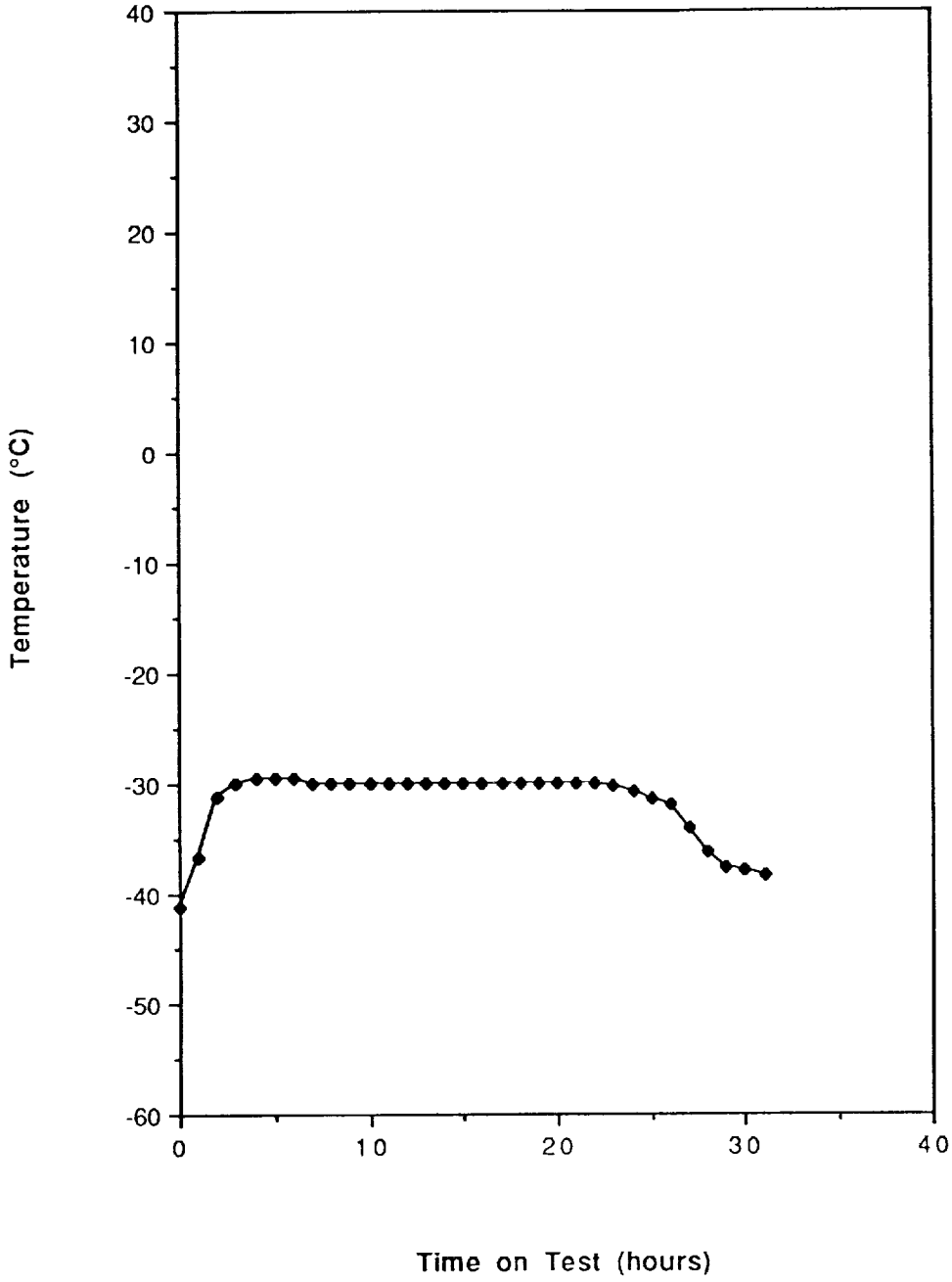
Temperature vs. Time on Test
SN 18272 - 1.5Ω/-40°C



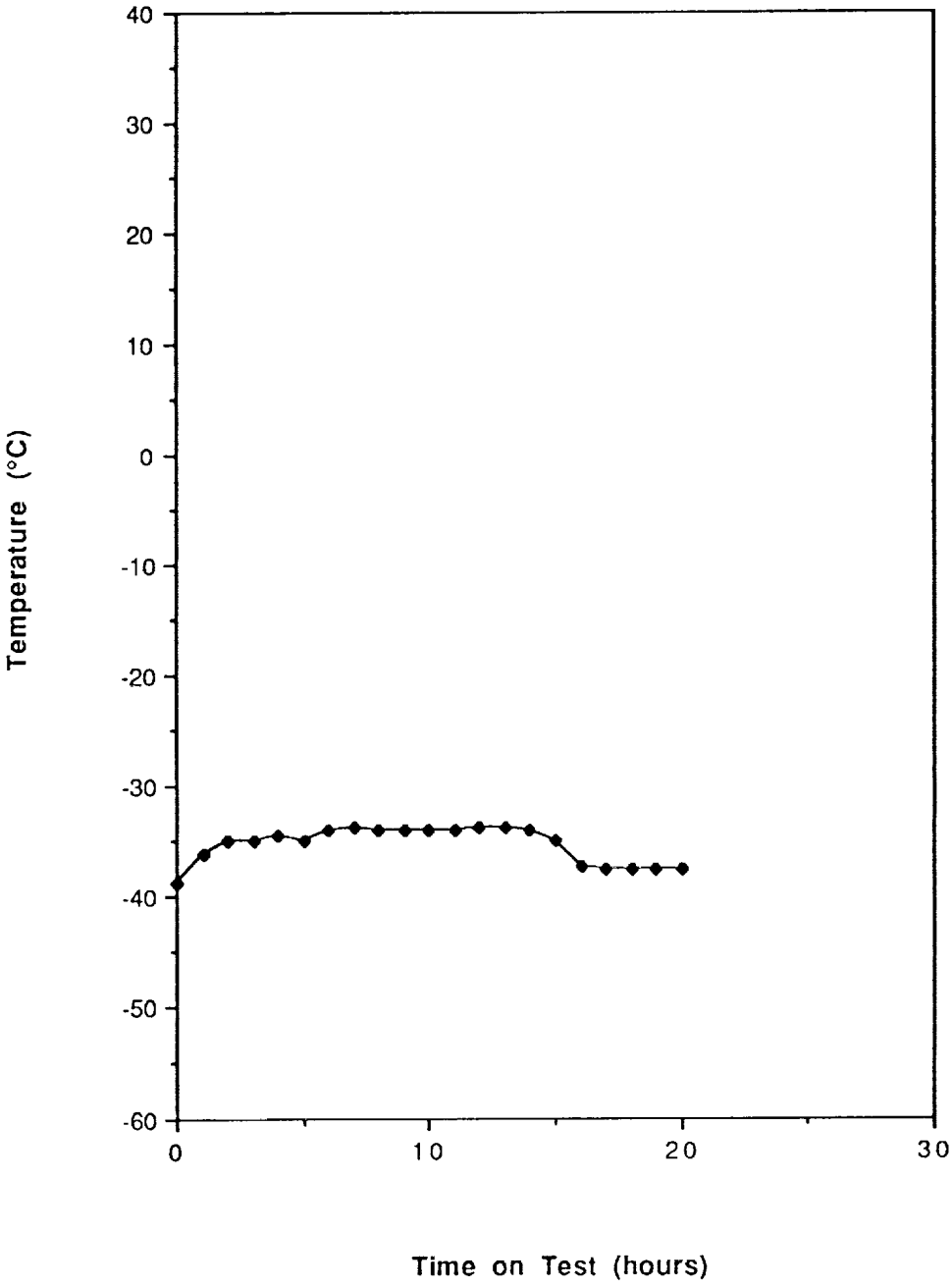
Temperature vs. Time on Test
SN 18226 - 5Ω/-40°C



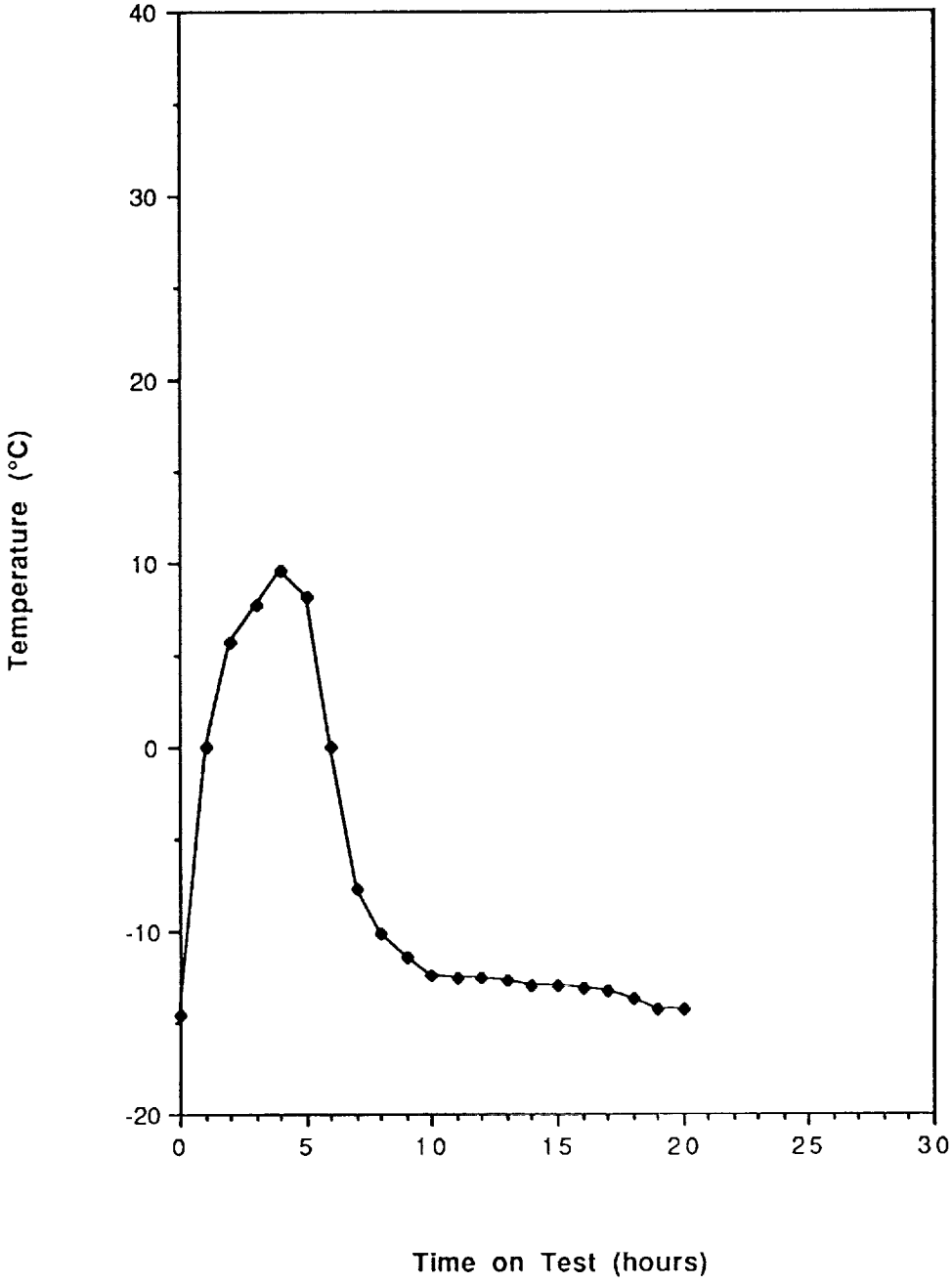
Temperature vs. Time on Test
SN 18314 - 5Ω/-40°C



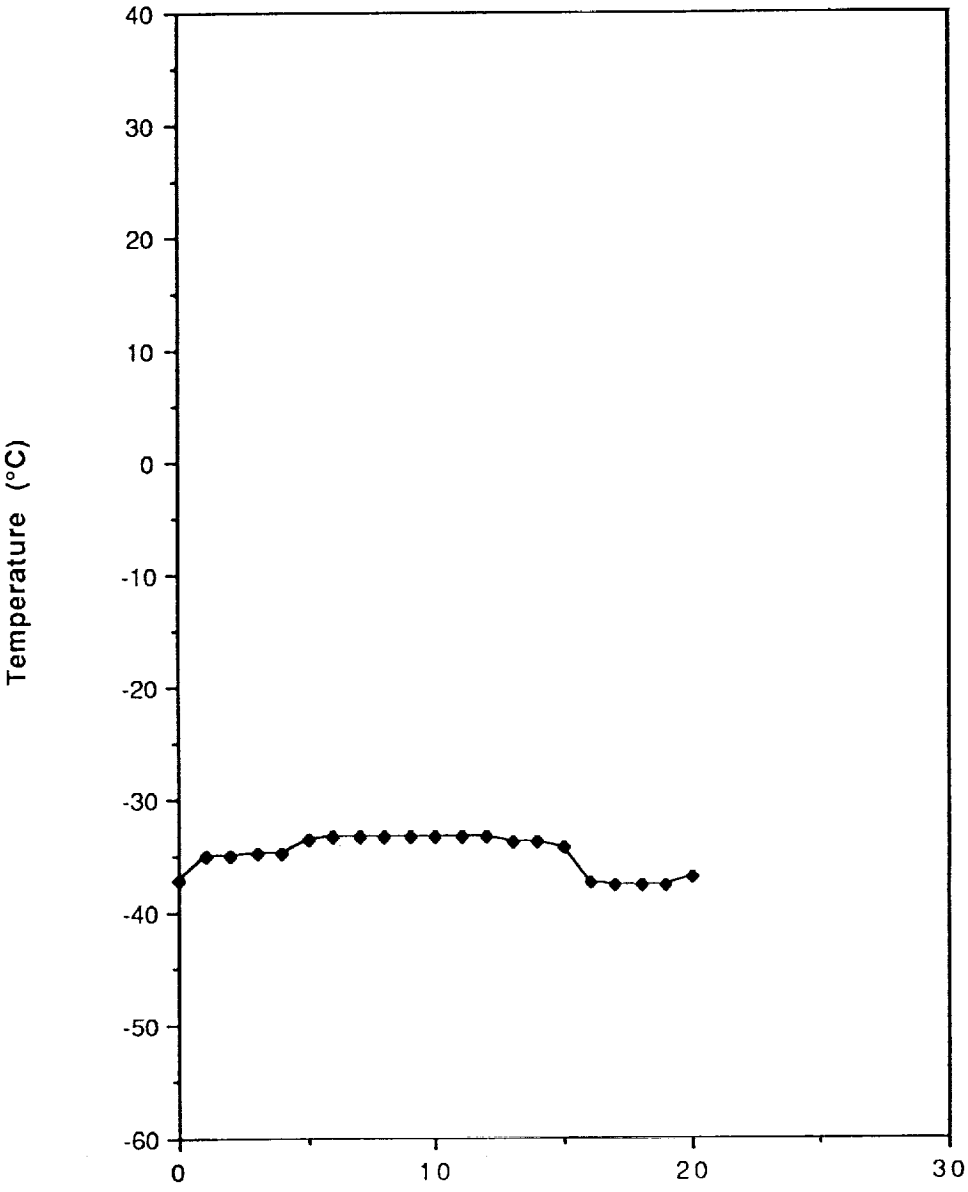
Temperature vs. Time on Test
SN 18352 - 10Ω/-40°C



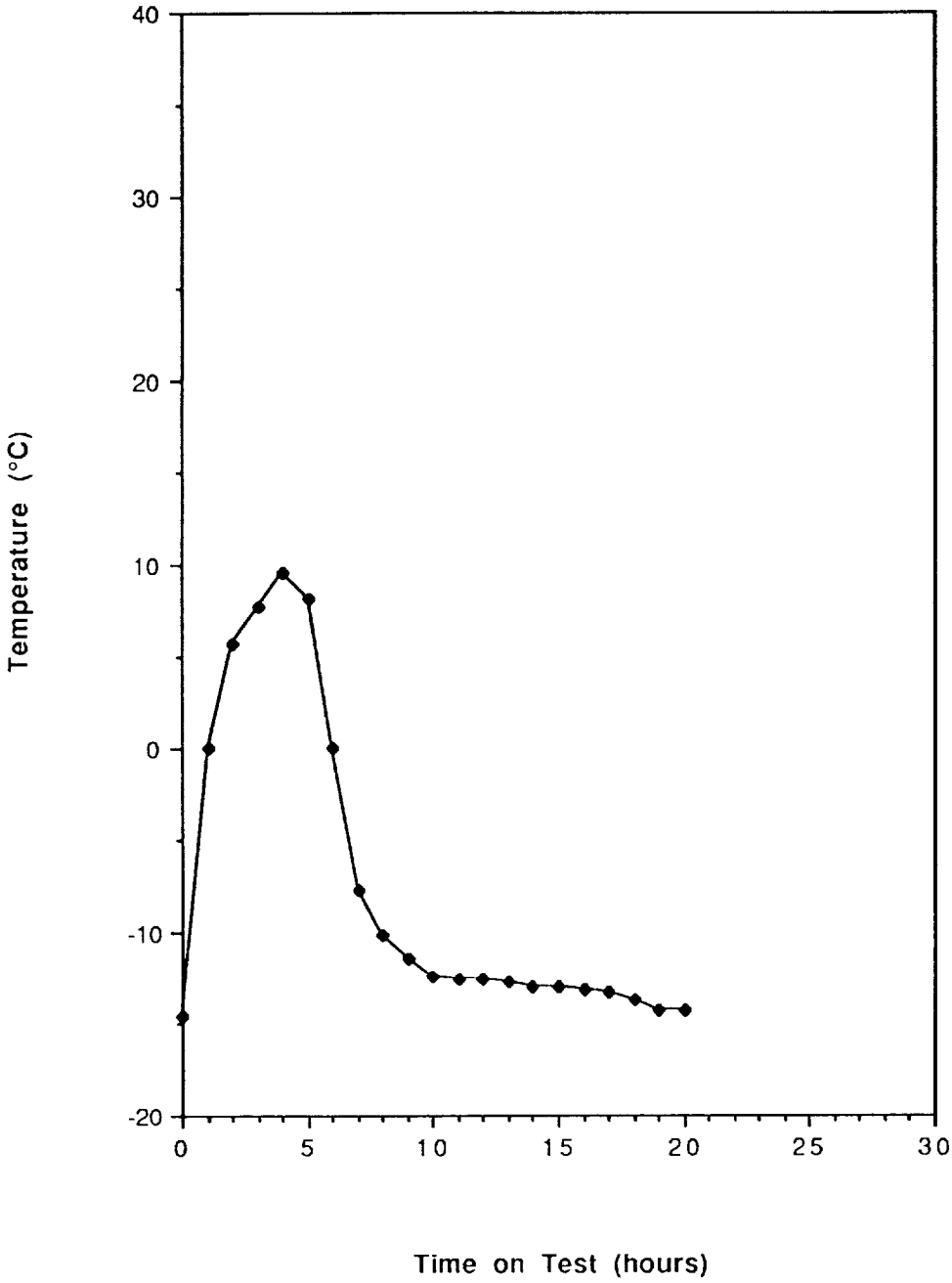
Temperature vs. Time on Test
SN 18408 - 1Ω/-18°C



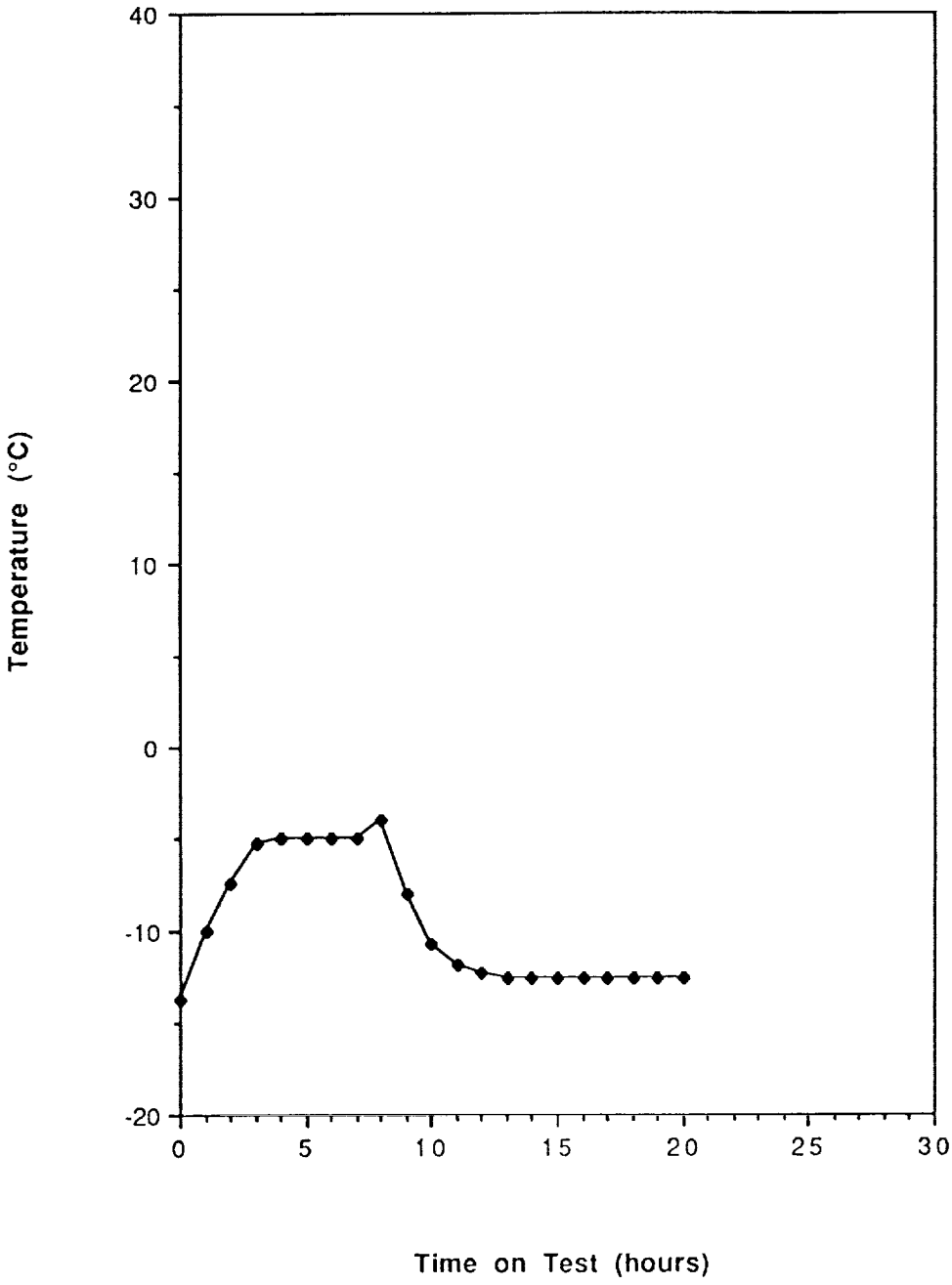
Temperature vs. Time on Test
SN 18356 - 10Ω/-40°C



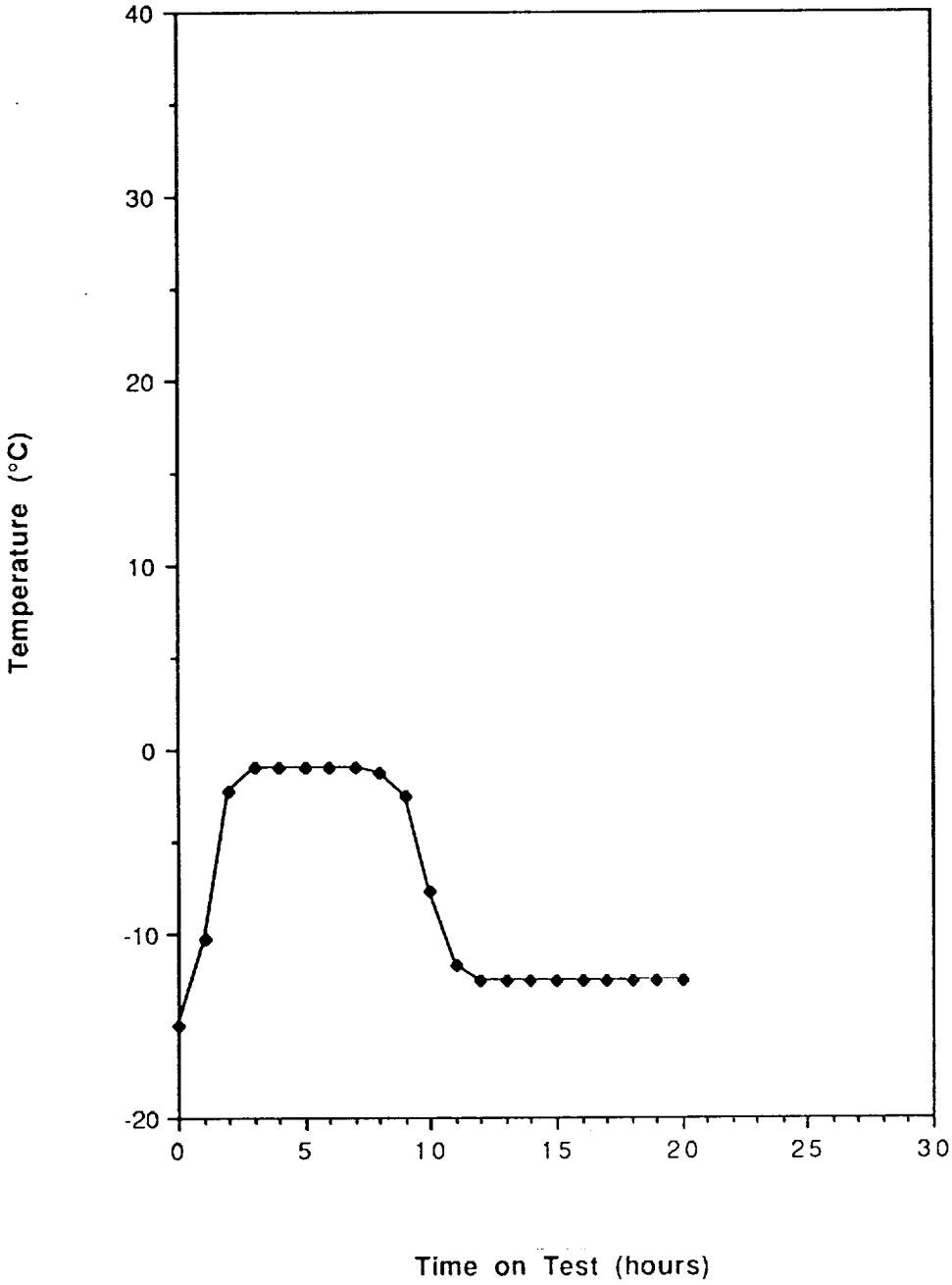
Temperature vs. Time on Test
SN 18414 - 1Ω/-18°C



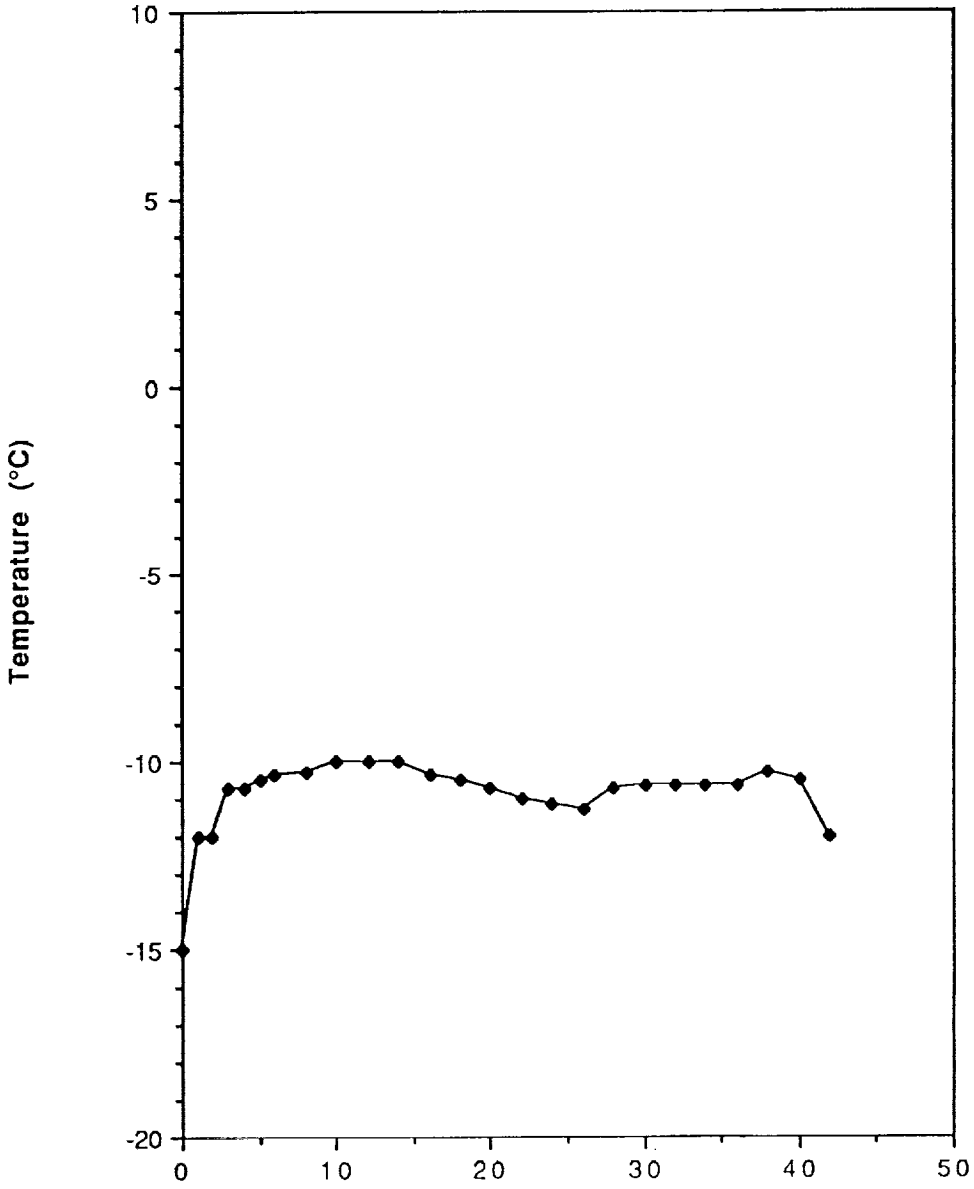
Temperature vs. Time on Test
SN 18420 - 1.5Ω/-18°C



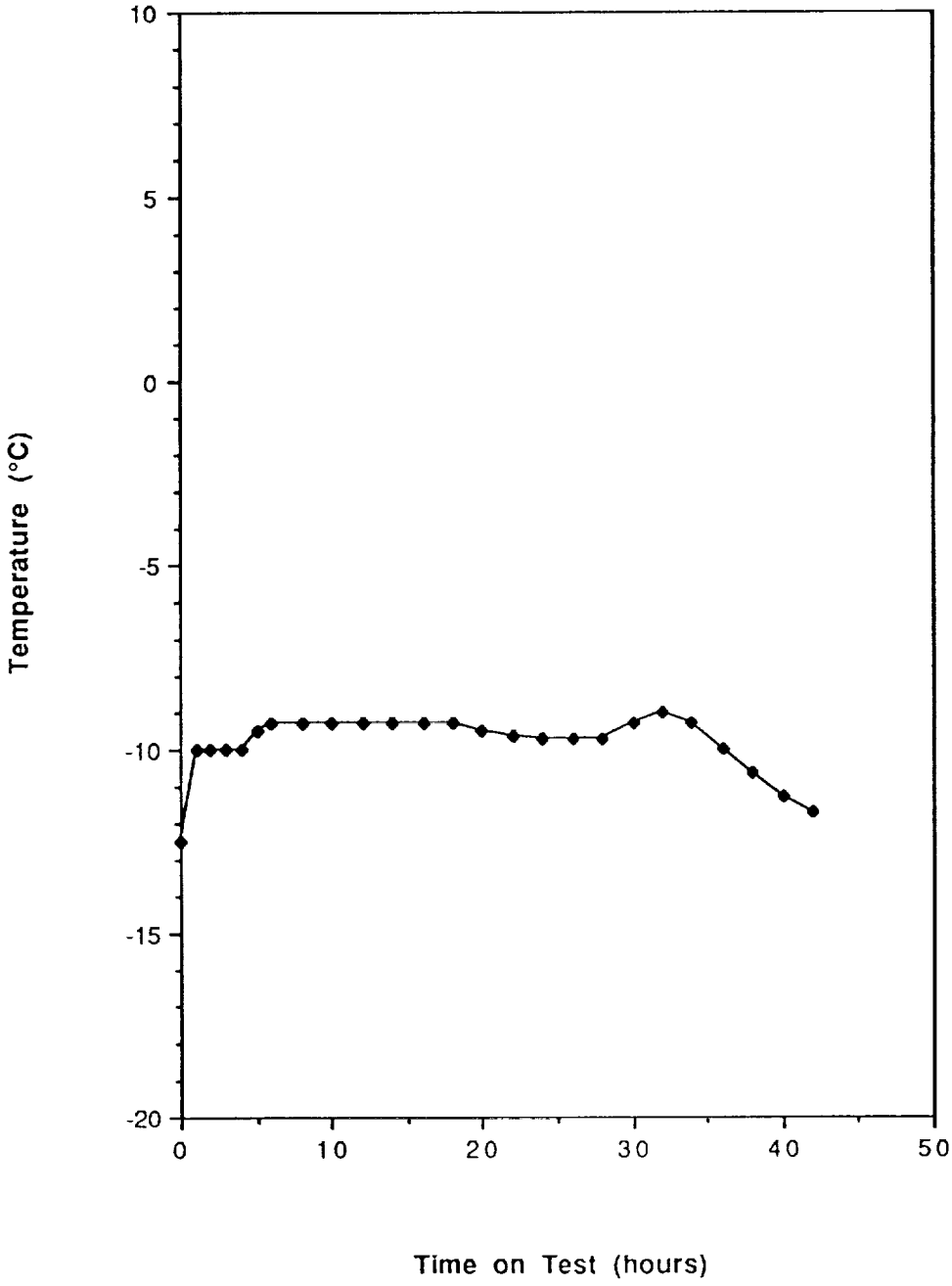
Temperature vs. Time on Test
SN 18424 - 1.5Ω/-18°C



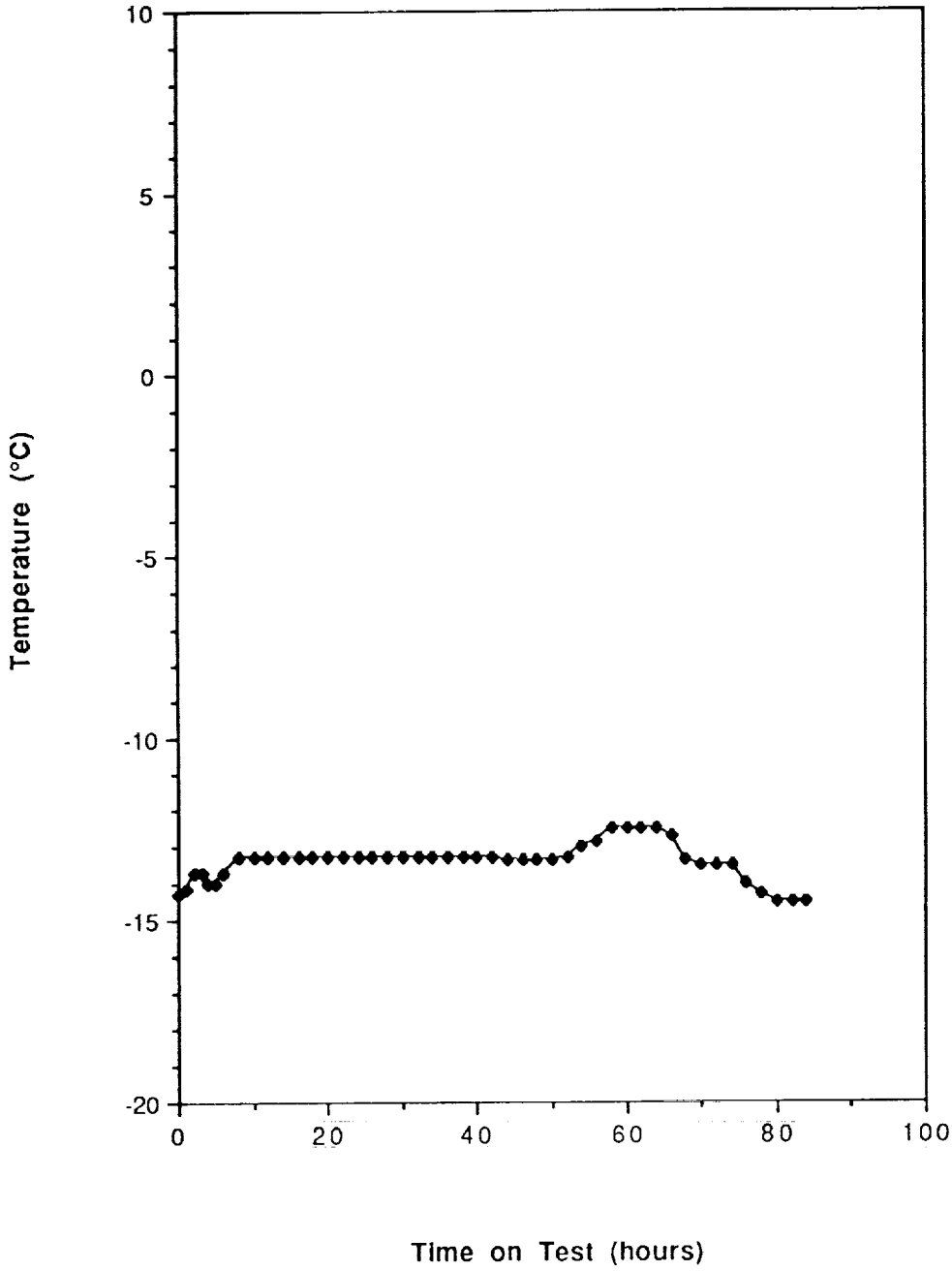
Temperature vs. Time on Test
SN 18290 - 5Ω/-18°C



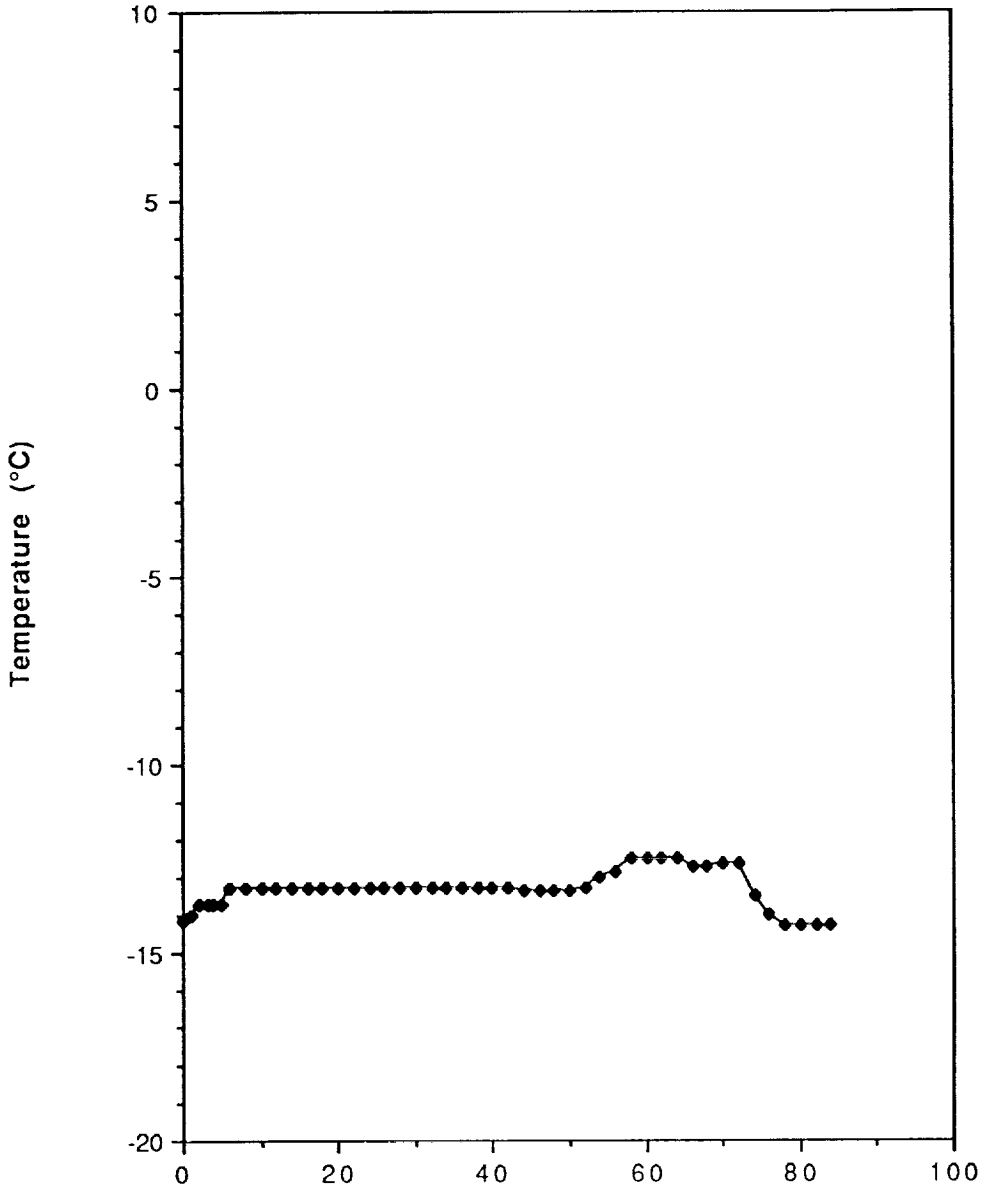
Temperature vs. Time on Test
SN 18294 - 5Ω/-18°C



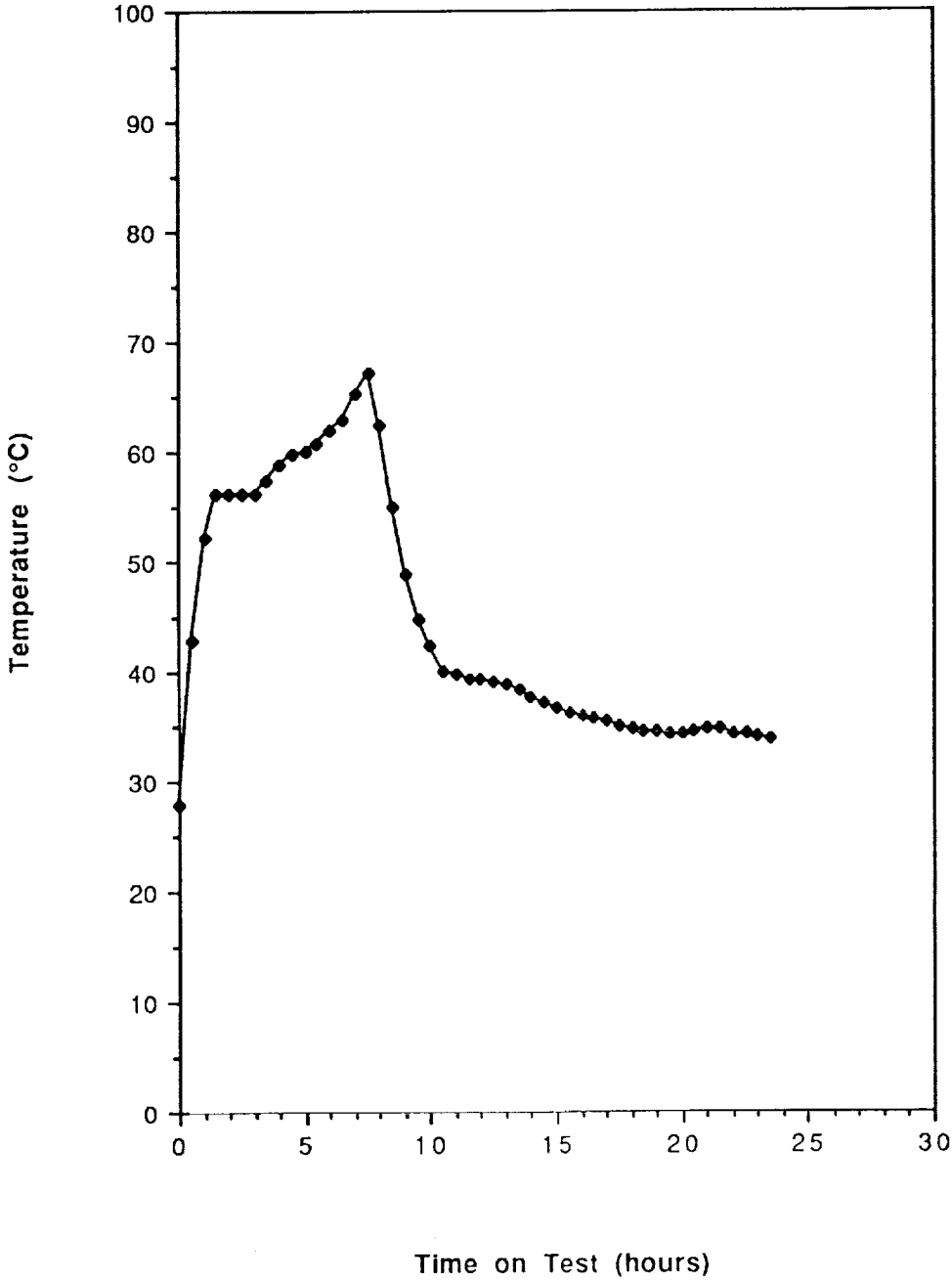
Temperature vs. Time on Test
SN 18430 - 10Ω/-18°C



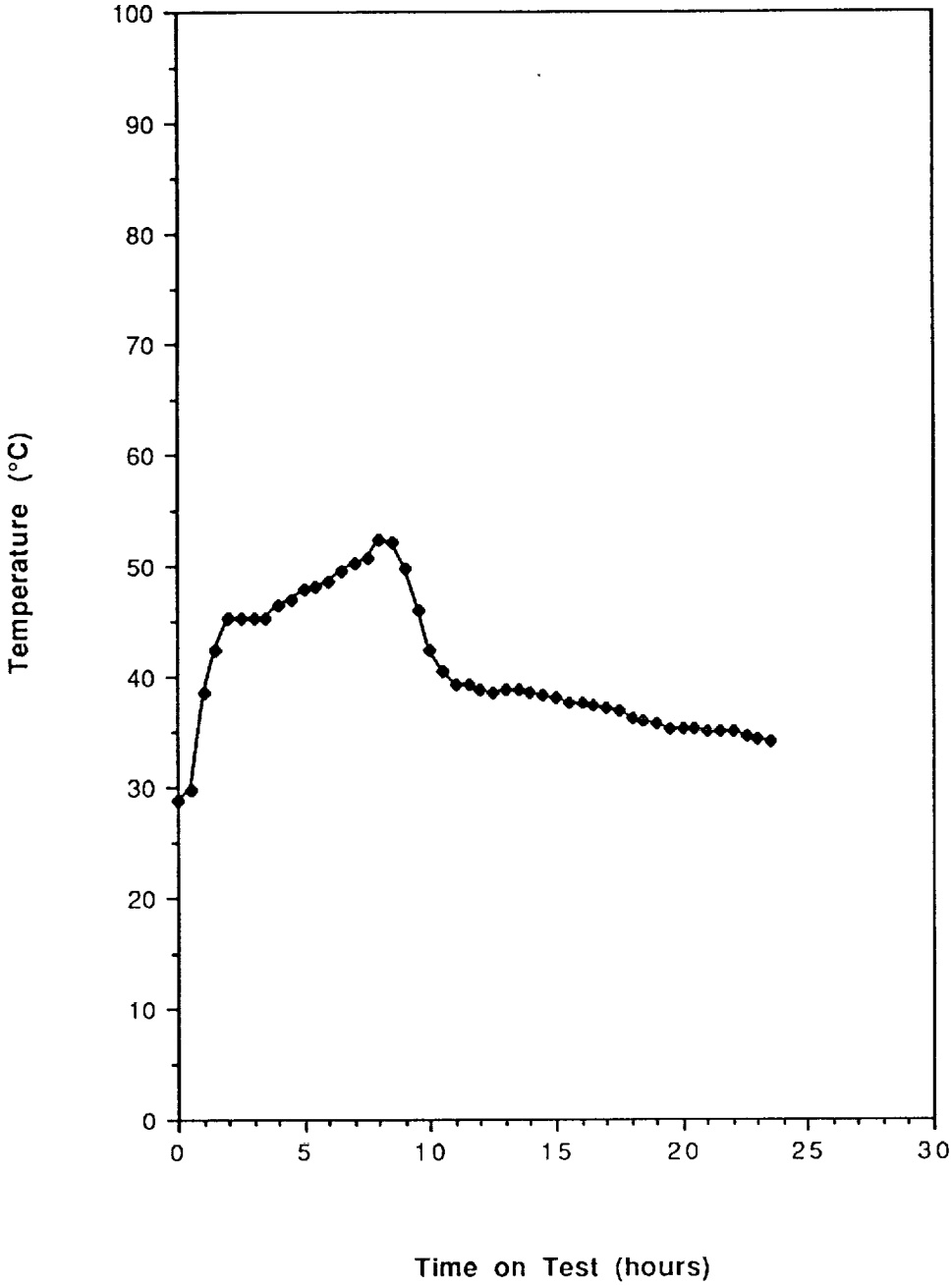
Temperature vs. Time on Test
SN 18434 - 10Ω/-18°C



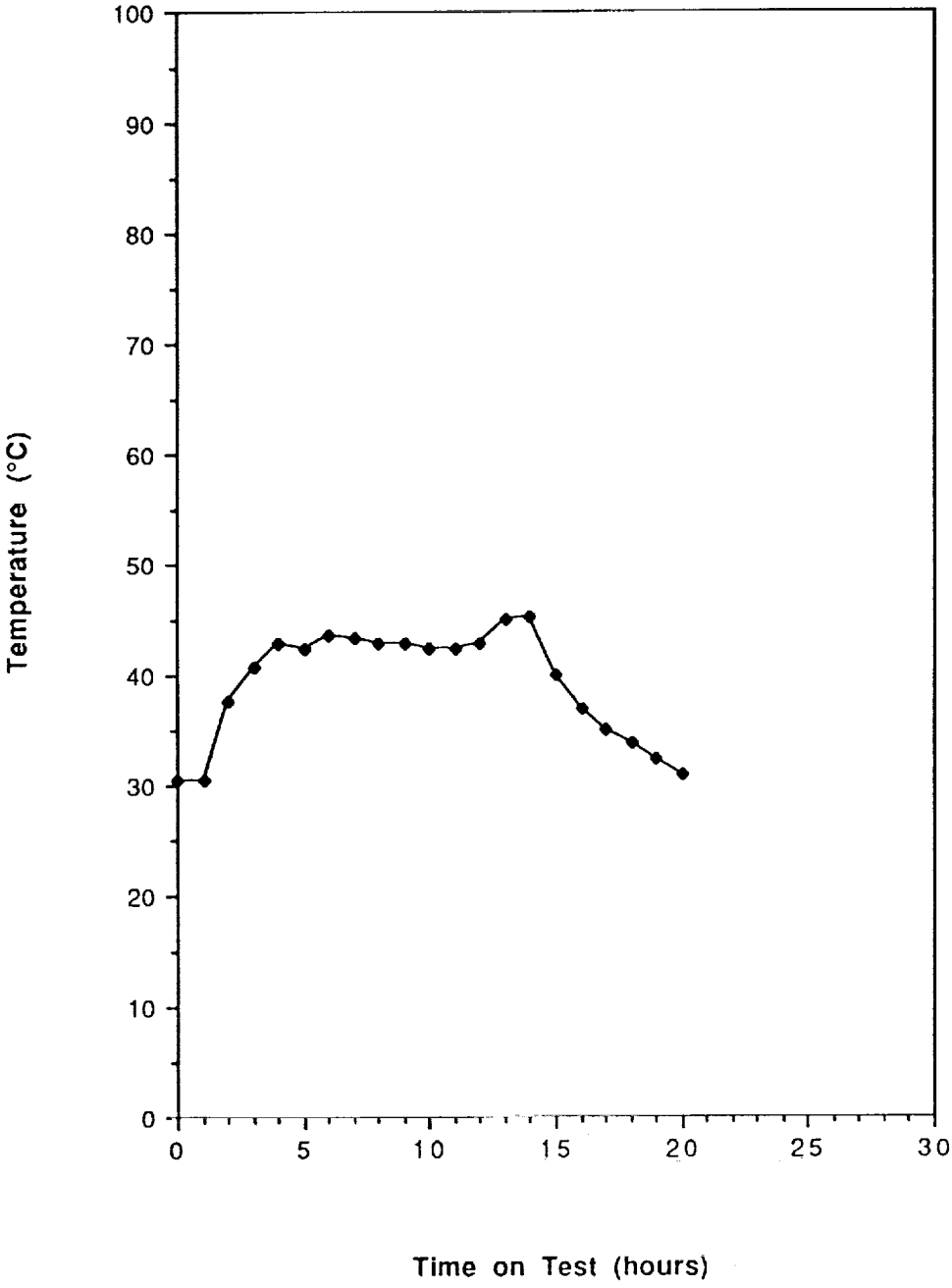
Temperature vs. Time on Test
SN 18192 - 1Ω/RT



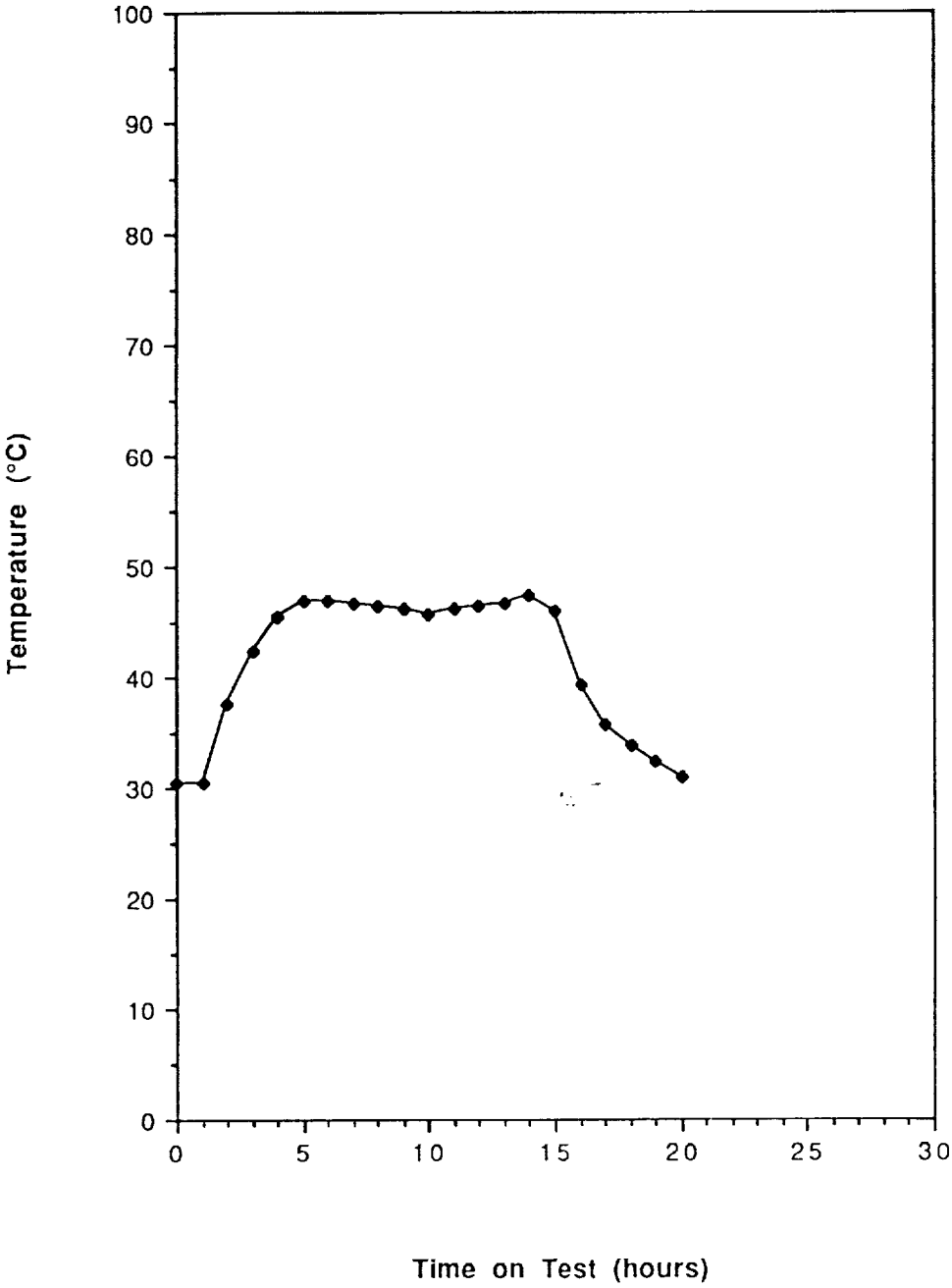
Temperature vs. Time on Test
SN 18196 - 1Ω/RT



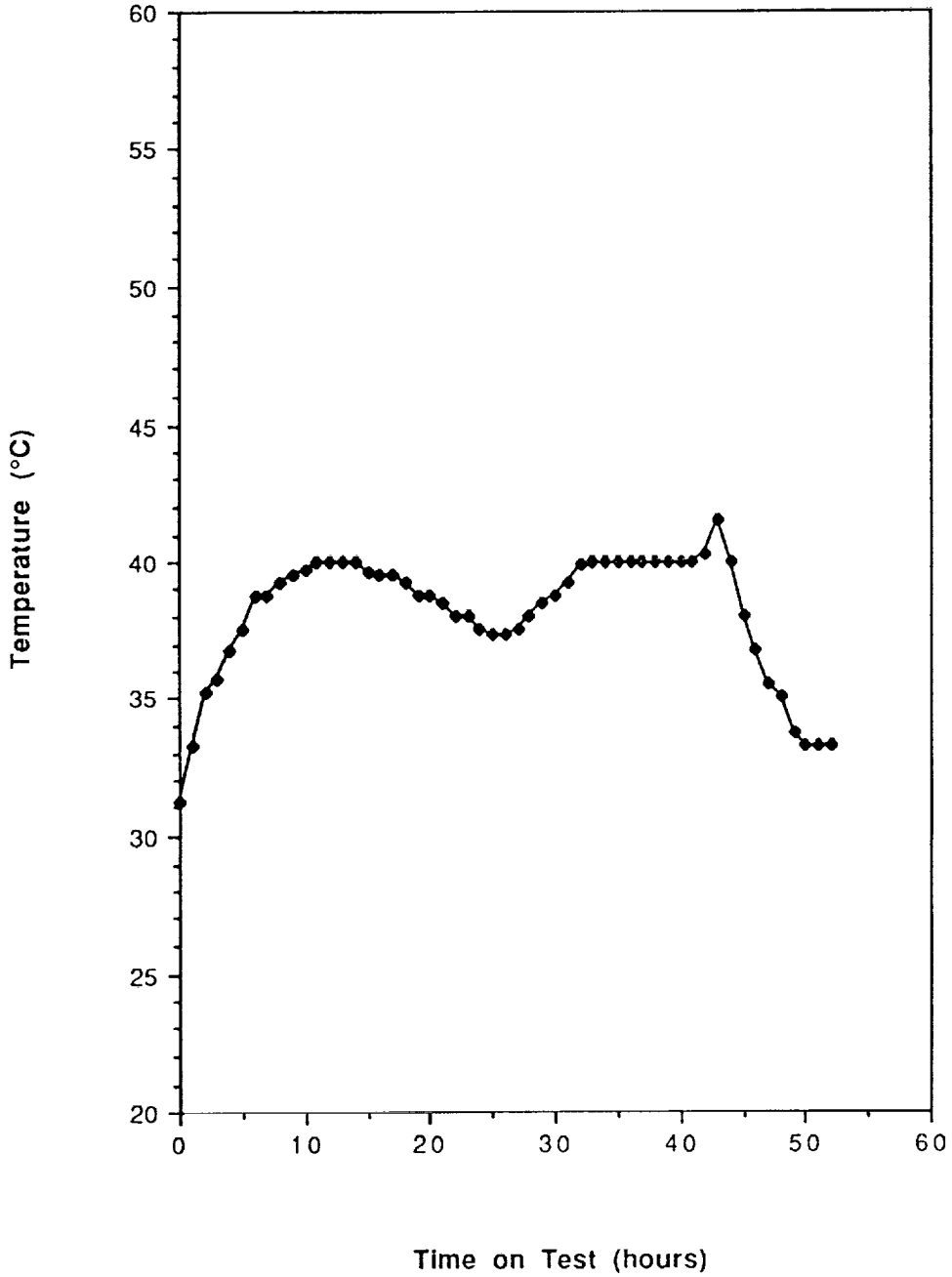
Temperature vs. Time on Test
SN 18236 - 1.5Ω/RT



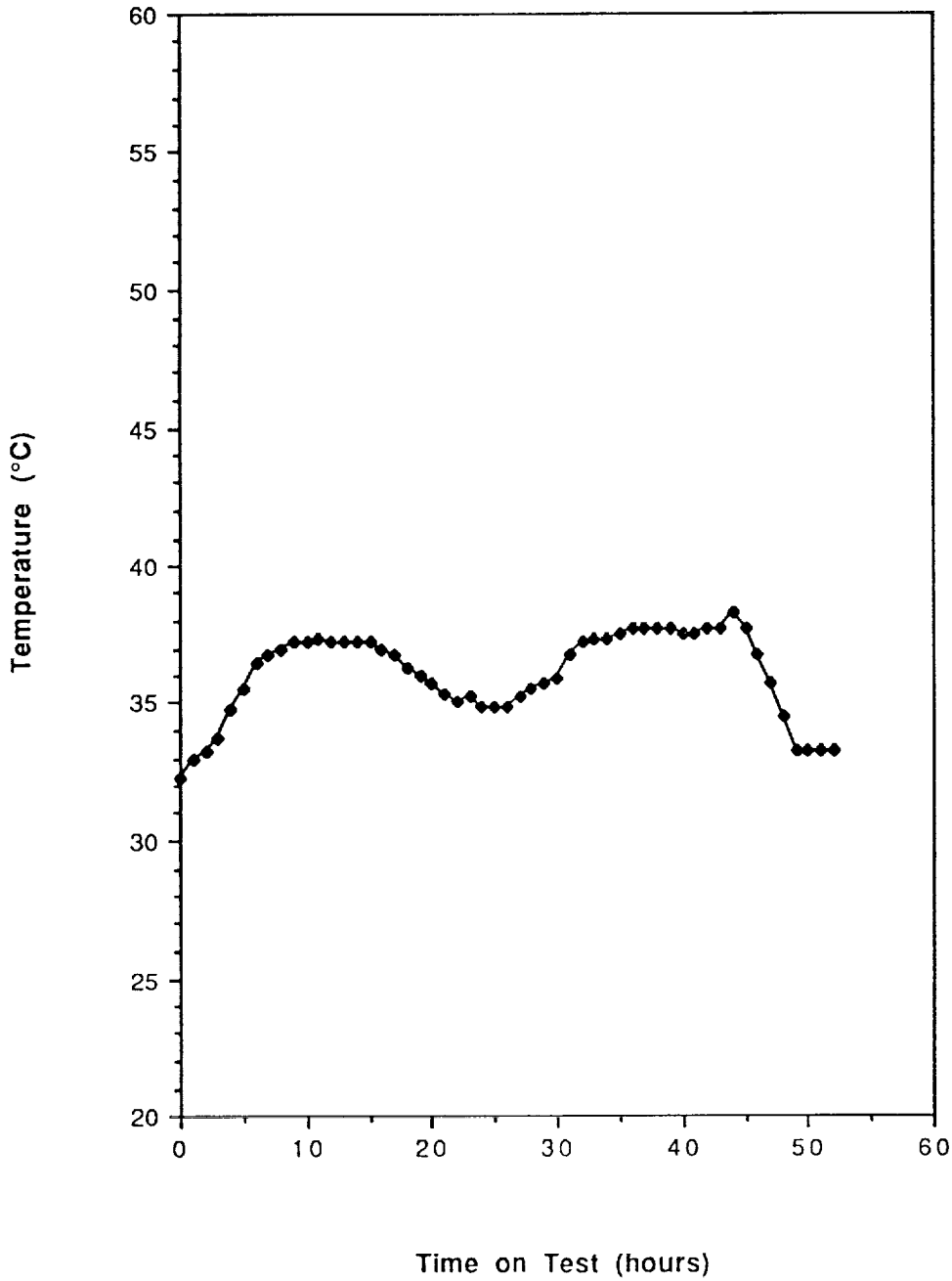
Temperature vs. Time on Test
SN 18240 - 1.5Ω/RT



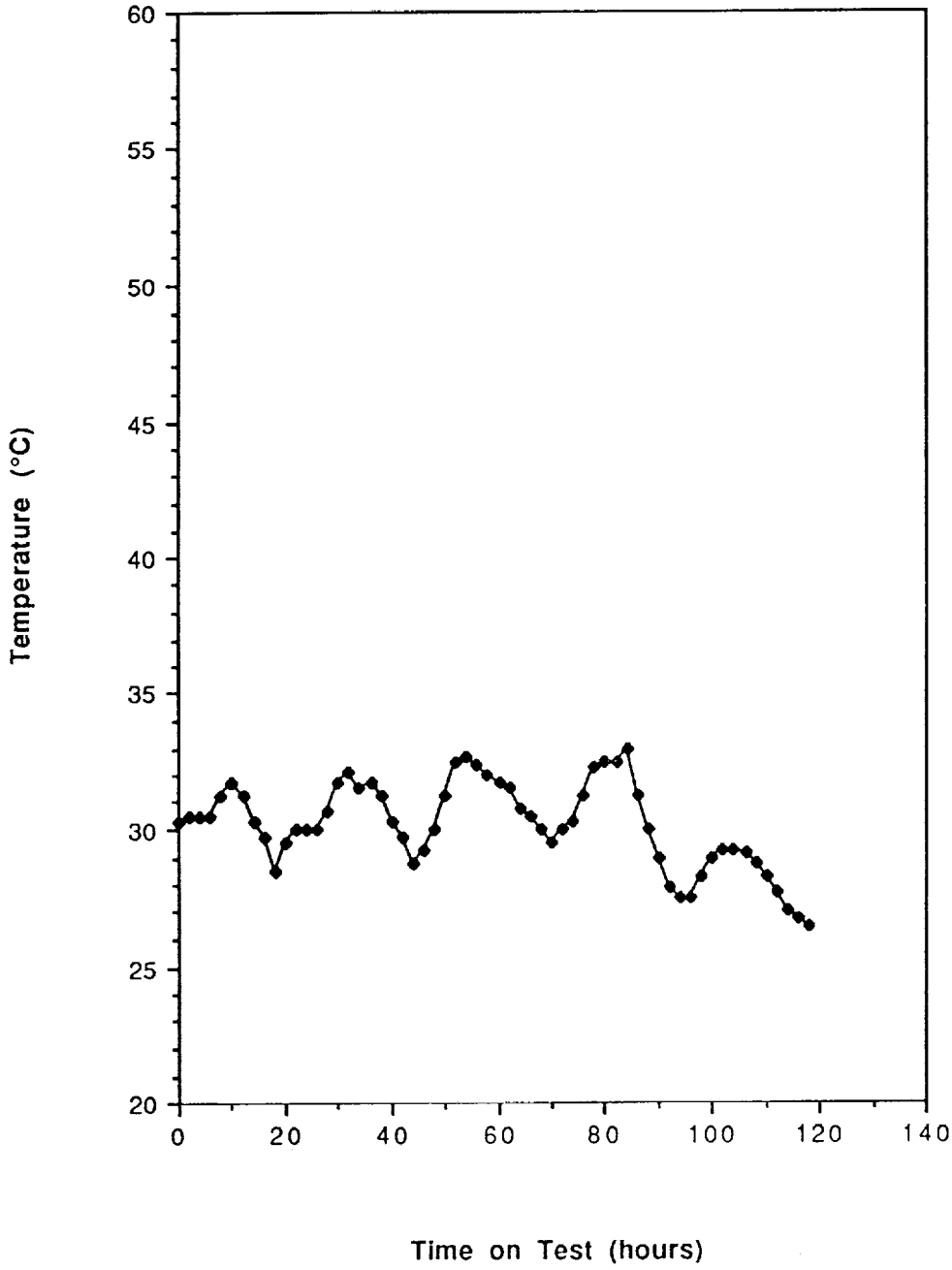
Temperature vs. Time on Test
SN 18278 - 5Ω/RT



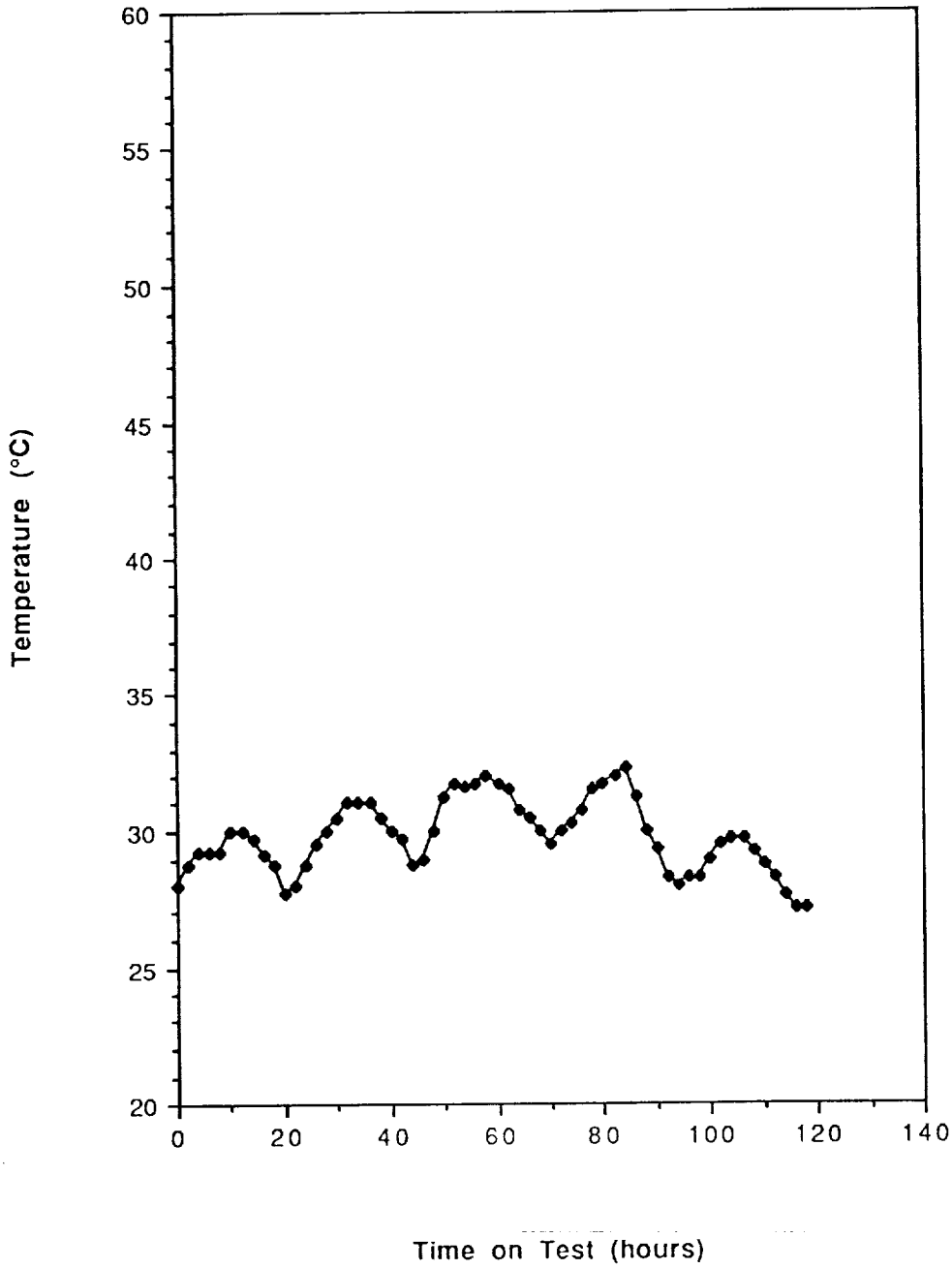
Temperature vs. Time on Test
SN 18282 - 5Ω/RT



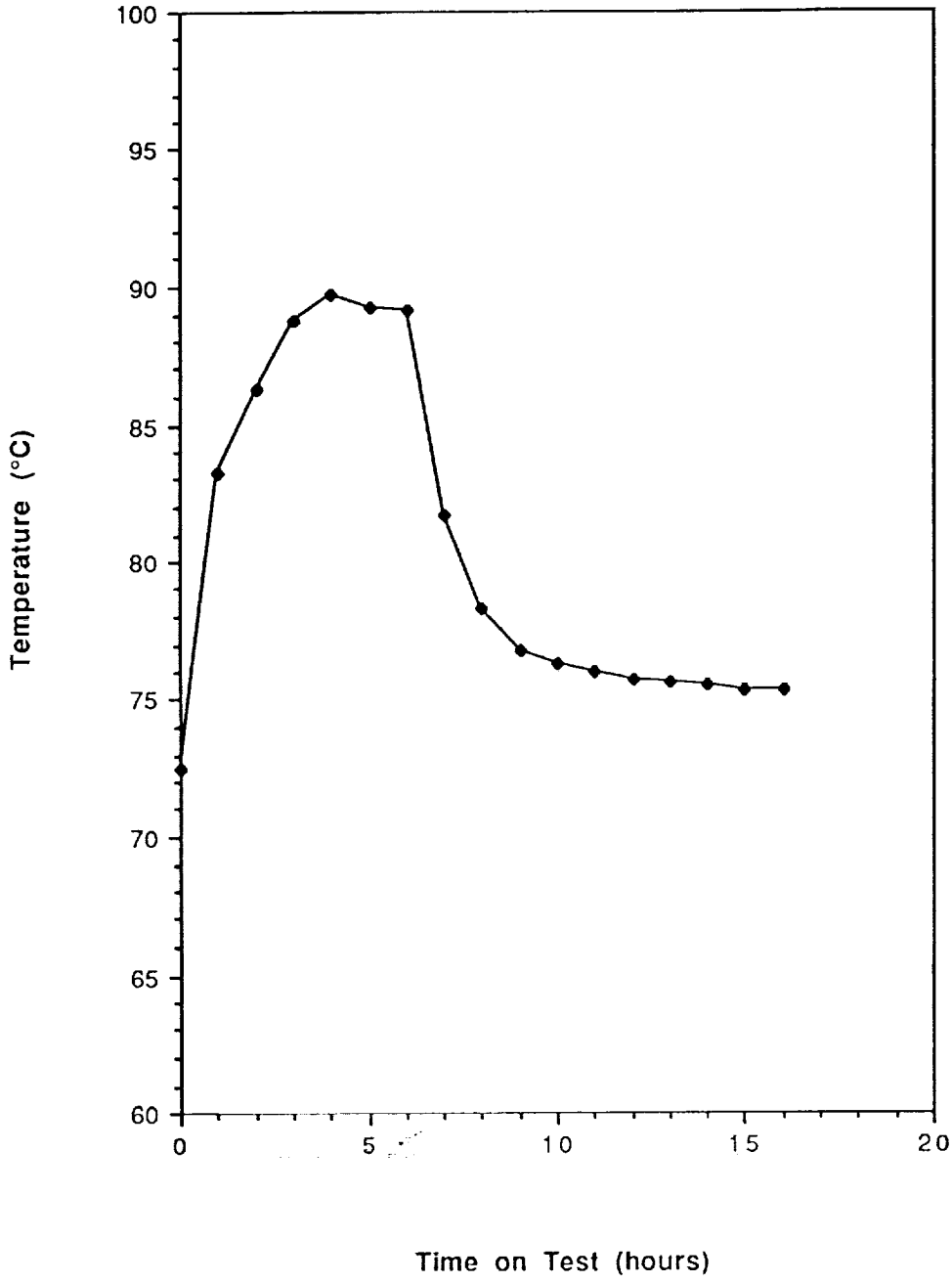
Temperature vs. Time on Test
SN 18320 - 10Ω/RT



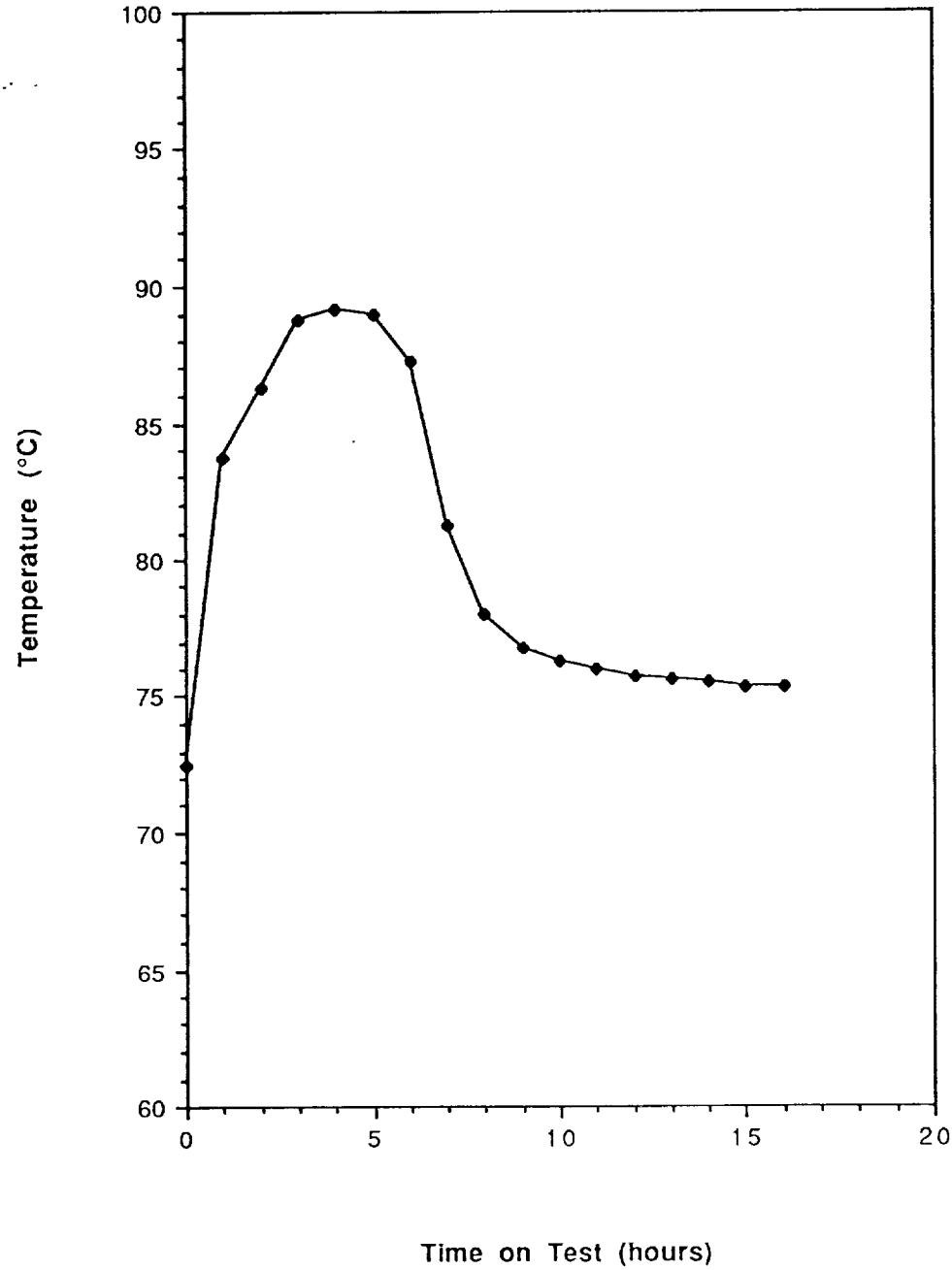
Temperature vs. Time on Test
SN 18324 - 10Ω/RT



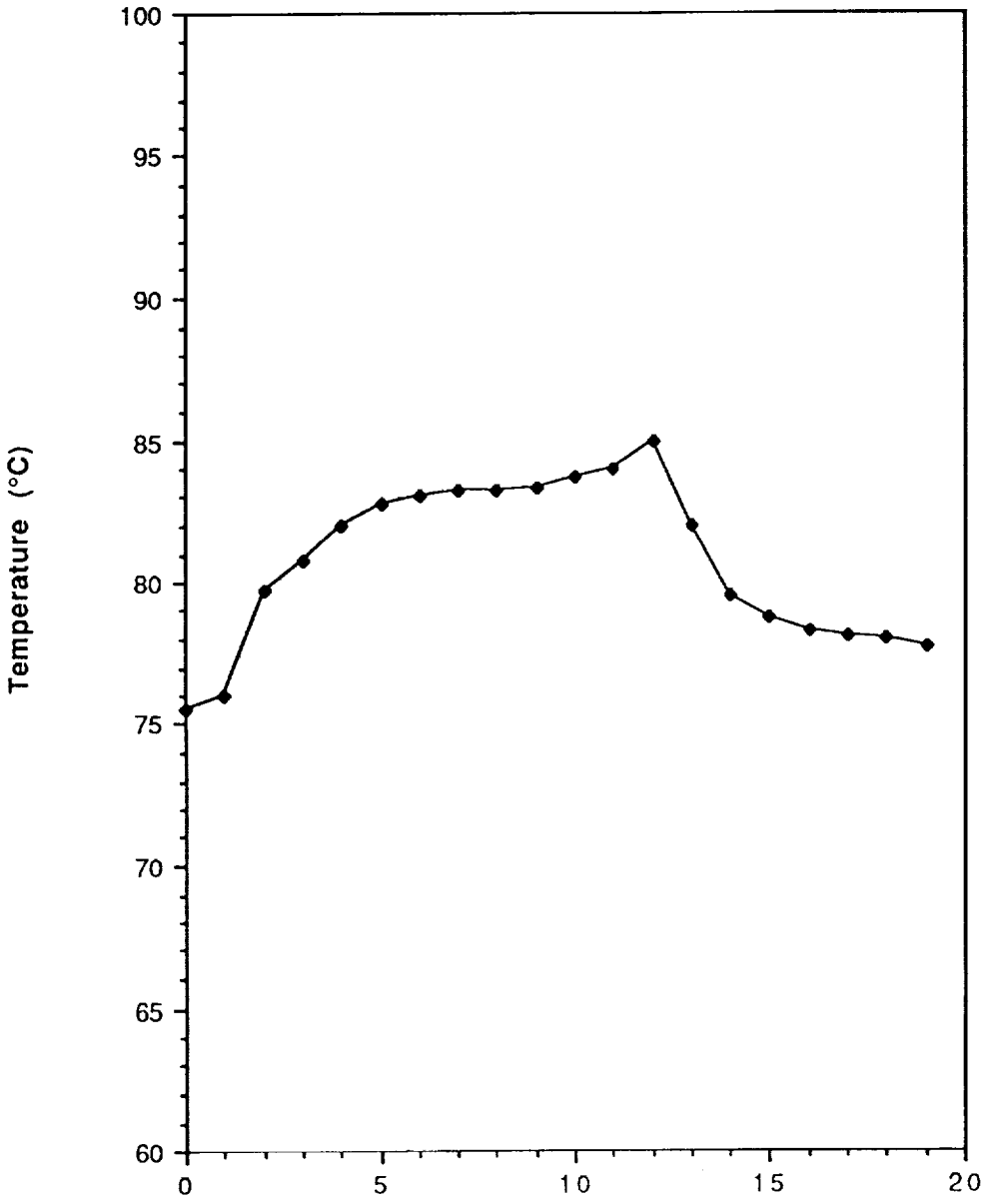
Temperature vs. Time on Test
SN 18216 - 1Ω/71°C



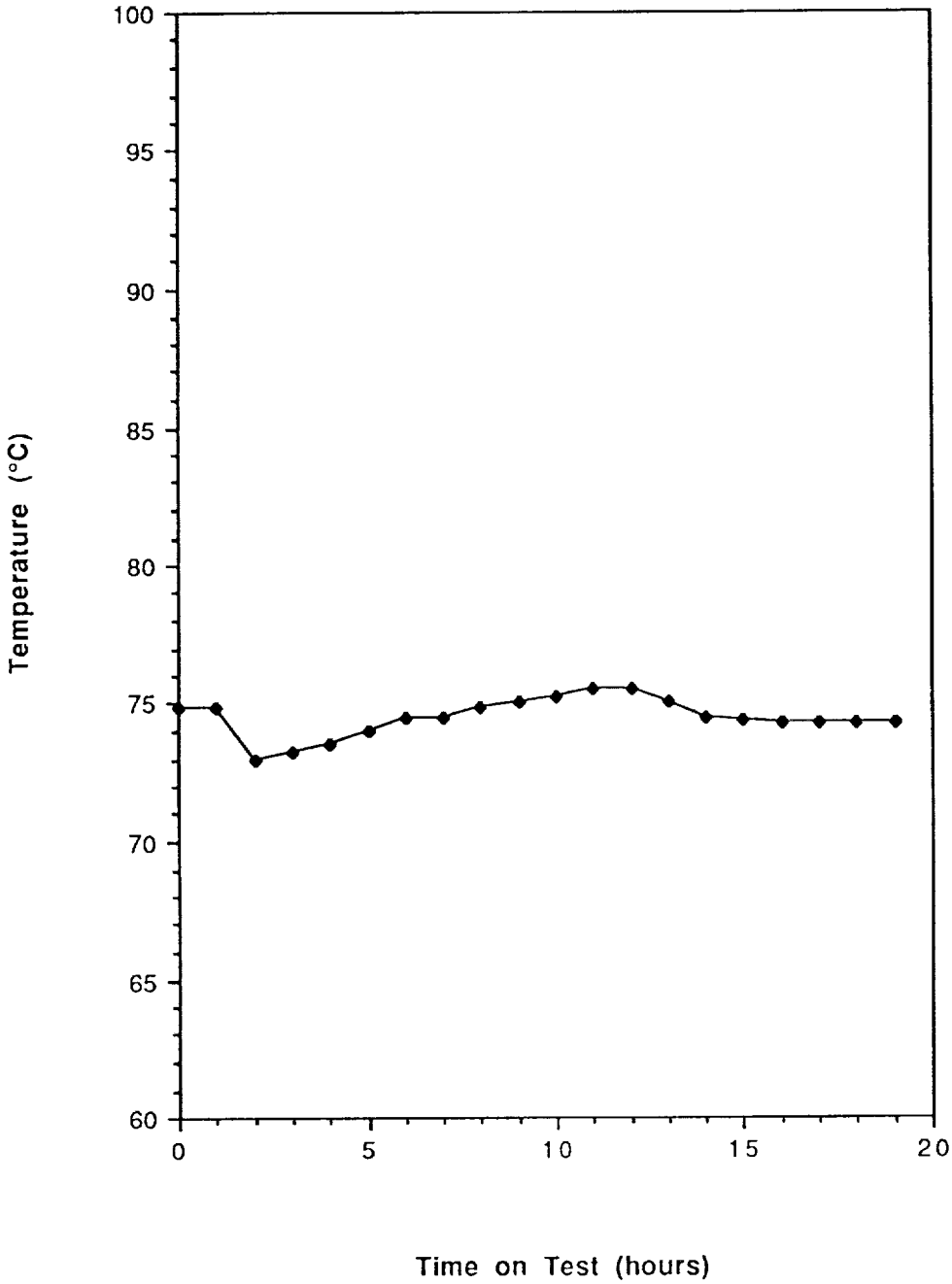
Temperature vs. Time on Test
SN 18220 - 1Ω/71°C



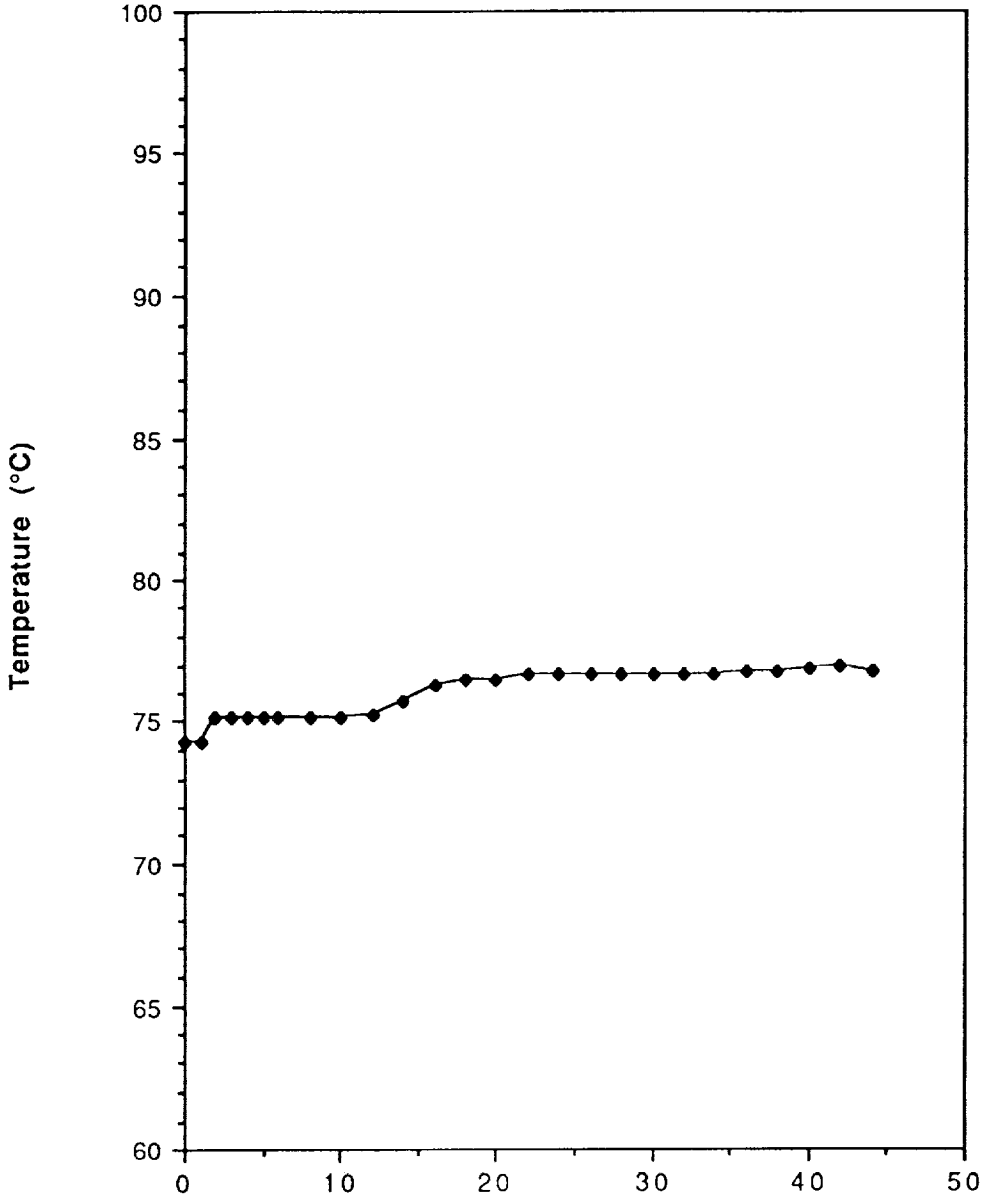
Temperature vs. Time on Test
SN 18258 - 1.5Ω/71°C



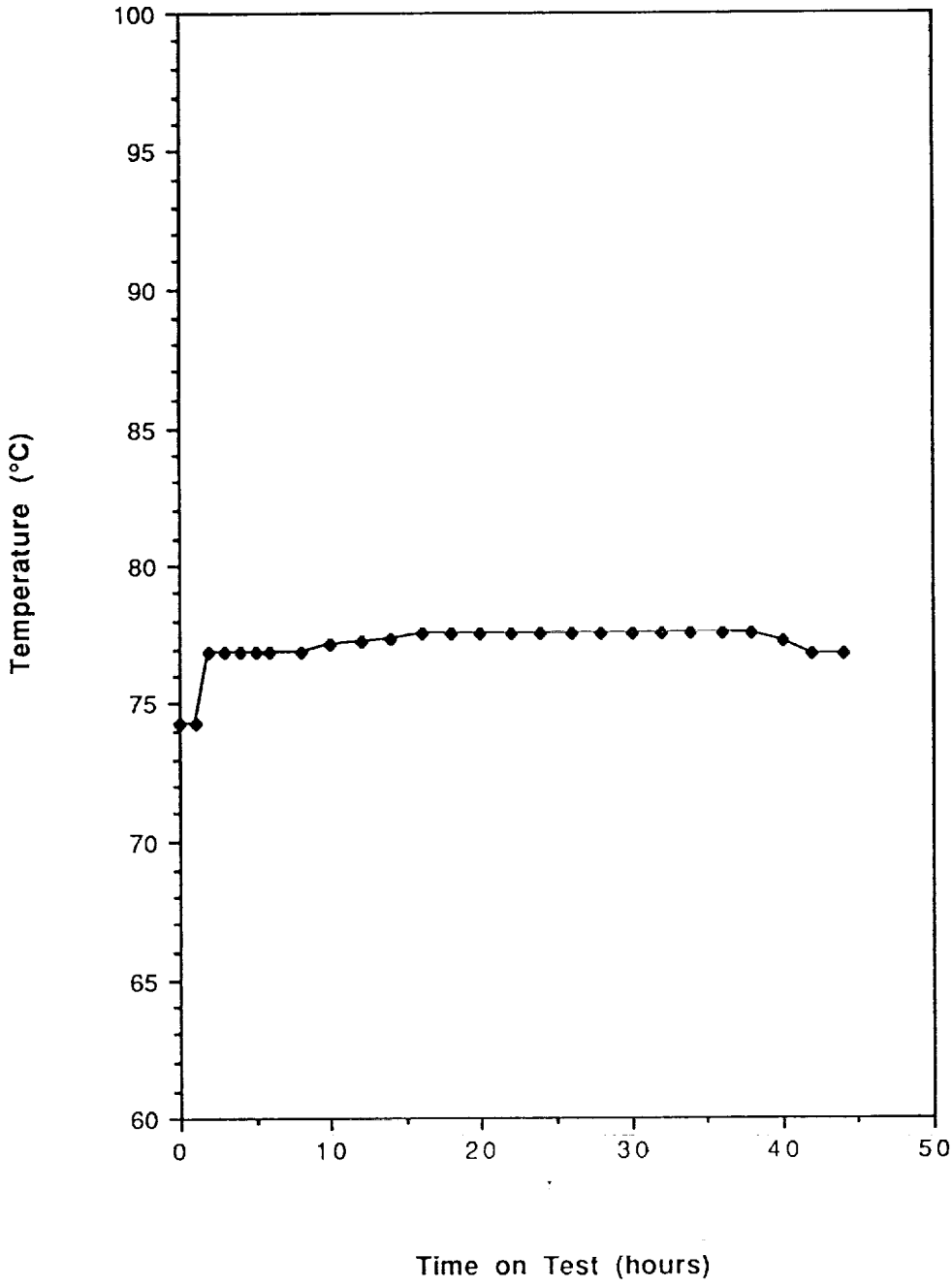
Temperature vs. Time on Test
SN 18262 - 1.5Ω/71°C



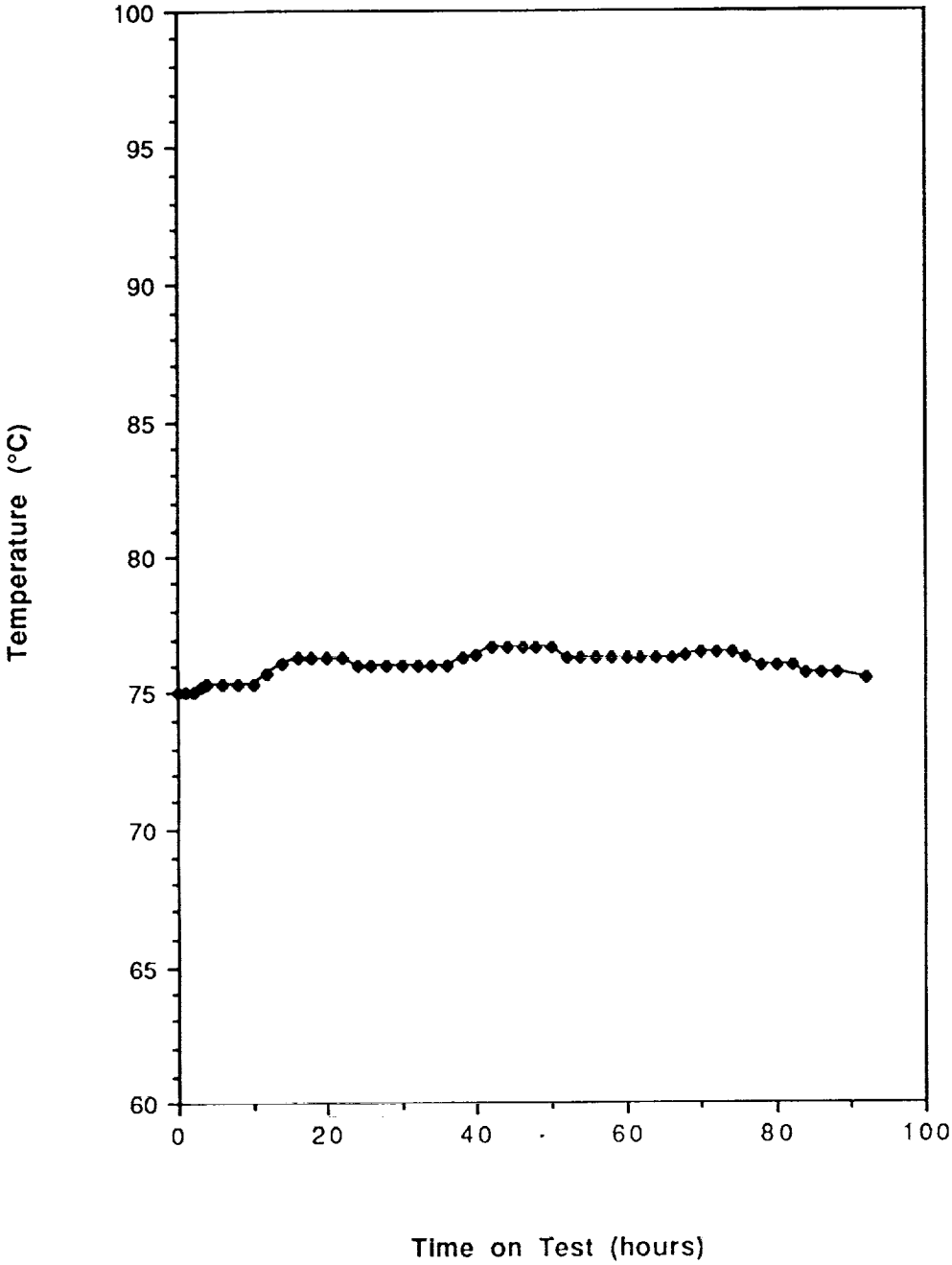
Temperature vs. Time on Test
SN 18300 - 5 Ω/71°C



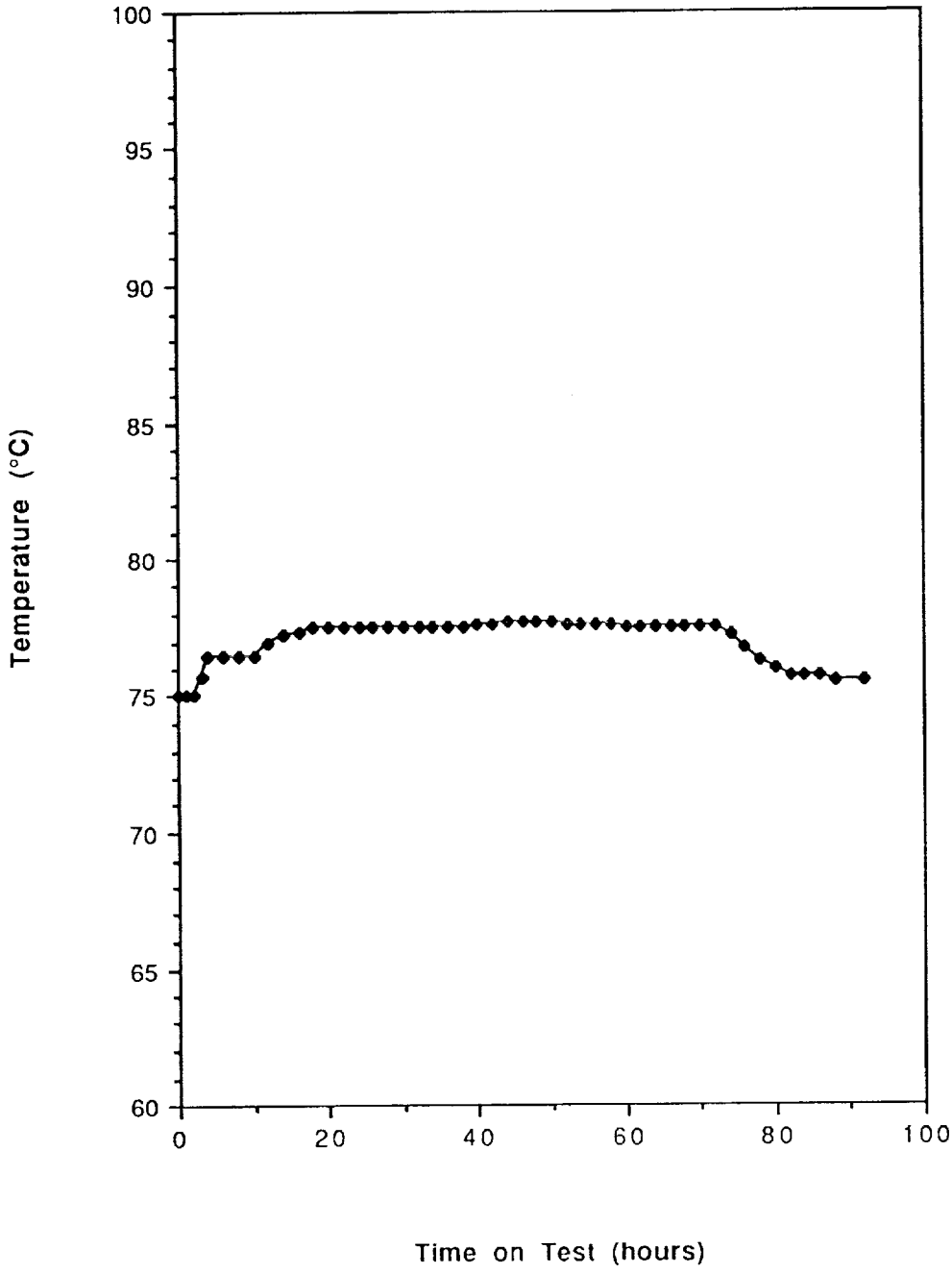
Temperature vs. Time on Test
SN 18304 - 5Ω/71°C



Temperature vs. Time on Test
SN 18342 - 10Ω/71°C



Temperature vs. Time on Test
SN 18346 - 10Ω/71°C



Appendix D

Quality Control Department Destructive Analysis Report 90-43-1

Quality Control Department Destructive Analysis Report 90 - 43 - 1

****

Model: BCX149 DD Date Code: E249B-36 RGN: NA

Reason for DA: Low DISCHARGE ON TEST

OCV Without Fuse: 3.65 20 Ω Load, Without Fuse: 2.85

Lead-to-Pin Weld: Undamaged (✓)

Crimp Weld: Undamaged (✓) Crimp Weld Not Required on this Model ( )

Anode-Lead-to-Case Welds: Undamaged (✓)

Examination of Anode Assembly:
VERY LIGHT SALTS

Approximate Lithium Utilization: 5 %

Examination of Cathode Assembly:
WET, FLEXIBLE. NO DISCHARGE PRODUCTS EVIDENT.

Examination of Separators: Not Possible Due to Discharge ( )
REDDISH STAIN ABOUT ½ WAY INTO ROLL.

Other Observations:
NO INDICATION OF DISCHARGE. WELDS AND WOUND ASSEMBLY ACCEPTABLE TO STANDARDS.

Technician: B. Welsh Date: 12 FEB 90 Page 1 of 1
Dist: D. Sieminski ( ), S. Ebel ( ), R. Samit ( ), R. Neumann ( ), M. Pyszczek ( )
P. Krehl ( ), M. Zelinsky ( ), D. Spillman ( ), S. MEYER ,

Appendix E

Short Circuit Test Report 90-014

RELIABILITY TEST RESULTS

MODEL:	BCX149DD (3B2085-XA)	DATE: 21FEB90	REPORT NO: 90/014

TEST: SHORT-CIRCUIT (REF: NAS9-18142)

ORIGINATOR: S. Meyer (REF: E.I/TR#89-111)

PURPOSE:

The purpose of these tests is to satisfy the requirements as stated in NASA Contract NAS9-18142, Section C (statement of work), Item D Task 4 (cell abuse tests), Para 1 (short-circuit tests).

PARAMETERS:

Cell short-circuit tests are to be performed on ten cells each at resistances of 500 milliohms, 100 milliohms, and 50 milliohms at both room temperature and 71°C (total = 60 cells). Cell voltage, current, and skin temperature were monitored and recorded. Cell temperature was monitored utilizing a type K thermocouple taped to the side of the cell approximately midpoint between the ends. Tests were terminated 15 minutes after the temperature peaked and began to decrease. Cells not destroyed or damaged by this test were returned and discharged at room temperature under a 20 ohm load.

RESULTS:

See Figures 1 - 6

NOTE: Two of the test conditions were terminated per S. Meyer due to the fact that violent reactions causing severe damage to ovens occurred. These reactions occurred on cells being tested at 71°C under 50 milliohm and 100 milliohm loads. . This information was relayed to NASA by S. Meyer.

SUBMITTED BY: T. Humphrey	DATE: 27FEB90
APPROVED BY: N. C. Strand	DATE: 27 Feb 90
DISTRIBUTION: S. Meyer, E. Takeuchi, W. Clark	PAGE 1 OF 7

FORM NO. 7044/0783 "REV A"

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 1 - 50 Milliohm
SHORT CIRCUIT TEST
AT ROOM TEMPERATURE
BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
33	55	B249C	3.77	12.5	7:42	116.0	28:21	NO PHYSICAL CHANGE
47	54	B249A	3.76	13.2	1:18	109.5	23:54	NO PHYSICAL CHANGE
6	54	C249B	3.76	11.3	0:48	85.0	26:24	NO PHYSICAL CHANGE
26	48	D249C	3.74	18.8	13:18	150.0	15:18	BOTTOM OF CASE SLIGHTLY SWELLED
9	48	A249B	3.75	15.3	0:02	No Significant Temperature Rise		LOSS OF INTERNAL CONTINUITY 48 SEC AFTER SHORT WAS APPLIED
47	52	D249B	3.73	10.4	11:57	113.5	21:24	NO PHYSICAL CHANGE
2	48	D249A	3.75	12.3	10:42	112.5	24:33	NO PHYSICAL CHANGE
38	48	E249B	3.75	10.9	10:00	96.0	20:45	NO PHYSICAL CHANGE
46	48	A299B	3.77	14.5	1:24	64.5*	8:27*	*8MIN 27 SEC AFTER SHORT APPLIED, THERMOCOUPLE WIRE DISENGAGED FROM CELL
14	50	A299A	3.78	16.7	0:57	138.5	51:12	BOTTOM OF CASE SLIGHTLY SWELLED

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 2 - 100 Milliohm
SHORT CIRCUIT TEST
AT ROOM TEMPERATURE
BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
3	110	C249B	3.74	11.8	0:03	95.0	21:21	NO PHYSICAL CHANGE
1	108	D249B	3.74	15.4	1:12	111.5	17:30	NO PHYSICAL CHANGE
23	110	B249C	3.75	14.4	0:54	104.0	26:03	NO PHYSICAL CHANGE
32	109	E249A	3.74	14.1	0:42	106.0	19:45	NO PHYSICAL CHANGE
43	107	B249B	3.77	13.1	5:42	126.5	23:24	NO PHYSICAL CHANGE
32	135	A299B	3.78	14.7	0:21	No Significant Temperature Rise		LOSS OF INTERNAL CONTINUITY 54 SEC AFTER SHORT WAS APPLIED
31	126	C249C	3.75	15.4	0:02	45.0	4:24	LOSS OF INTERNAL CONTINUITY 3 MIN 30 SEC AFTER SHORT WAS APPLIED
3	121	E249B	3.75	11.1	8:48	95.0	22:06	NO PHYSICAL CHANGE
47	124	A249B	3.76	12.3	0:45	103.0	24:57	NO PHYSICAL CHANGE
48	121	A299A	3.78	6.7	0:54	121.0	24:27	NO PHYSICAL CHANGE

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 3 - 500 Milliohm
SHORT CIRCUIT TEST
AT ROOM TEMPERATURE
BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
32	505	C249C	3.75	5.6	<0:01	57.5	11:57	NO PHYSICAL CHANGE
9	528	B249A	3.76	5.6	<0:01	No Significant Temp. increase		NO PHYSICAL CHANGE
20	499	B249B	3.76	5.5	13:30	51.5	8:54	NO PHYSICAL CHANGE
35	507	D249A	3.75	3.3	3:24	38.5	261:21	NO PHYSICAL CHANGE
35	508	D249C	3.74	5.4	20:09	57.0	150:00	NO PHYSICAL CHANGE
9	500	A299A	3.77	5.9	2:30	51.0	89:00	NO PHYSICAL CHANGE
28	500	E249A	3.74	5.2	2:39	Thermocouple Malfunction No Temperature Data		NO PHYSICAL CHANGE
35	500	A299B	3.78	6.1	1:30	59.0	104:30	NO PHYSICAL CHANGE
2	497	D249B	3.74	5.7	2:00	58.0	155:00	NO PHYSICAL CHANGE
39	504	A249B	3.76	5.7	2:30	64.5	154:30	NO PHYSICAL CHANGE

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 4 - 50 Milliohm

SHORT CIRCUIT TEST AT 71°C

BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
19	52	E249B	3.72	16.0	0:02	No Significant Temp. increase		Loss of internal continuity 12 Sec after short applied
41	52	B249C	3.73	20.2	<0:01	No Significant Temp. increase		Loss of internal continuity 3 Sec after short applied
19	54	A249A	3.73	20.8	0:04	163.5	15:39	Loss of internal continuity 15 Min 39 Sec after short applied - case bulged
19	56	E249A	3.76	16.7	<0:01	No Significant Temp. increase		Loss of internal continuity 5 Sec after short applied
27	55	B249B	3.76	20.5	0:08	196.5	16:24	Loss of internal continuity 16 Min 24 Sec after short applied - case bulged
8	56	C249C	3.72	21.8	0:04	184.0	10:21	Case rupture occurred 10 Min 21 Sec after short applied
								NOTE: TESTING WAS TERMINATED PER S. MEYER

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 5 - 100 Milliohm

SHORT CIRCUIT TEST AT 71°C

BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
42	112	D249B	3.73	13.8	0:12	167.5	69:42	NO LEAK, VENT OR RUPTURE CASE BULGED
28	104	B249B	3.76	17.6	<0:01	198.0	31:48	NO LEAK, VENT OR RUPTURE CASE BULGED
17	108	E249A	3.76	14.4	<0:01	207.5	55:57	NO LEAK VENT OR RUPTURE CASE BULGED
32	101	D249C	3.74	16.8	0:33	209.0	40:15	CASE RUPTURE OCCURRED 40 MIN 15 SEC AFTER SHORT APPLIED
20	111	B249A	3.76	15.4	0:02	149.5	23:15	CASE RUPTURE OCCURRED 23 MIN 15 SEC AFTER SHORT APPLIED
								NOTE: TESTING WAS TERMINATED PER S. MEYER
								RTR# 90/014 PAGE 6 OF 7

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 6 - 500 Milliohm

SHORT CIRCUIT TEST AT 71°C

BCX149DD (3B2085-XA)
NAS9-18142

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER	PRETEST RESISTANCE MEASUREMENT (mΩ)	DATE CODE	OCV BEFORE TEST	PEAK CURRENT (Amp)	TIME TO PEAK CURR (Min:Sec)	PEAK TEMP (°C)	TIME TO PEAK TEMP (Min:Sec)	RESULTS
26	518	A299A	3.75	6.0	0:30	92.0	49:00	NO PHYSICAL CHANGE
29	517	D249C	3.74	5.6	0:27	91.0	26:51	NO PHYSICAL CHANGE
21	499	A299B	3.76	4.35	1:00	82.5	58:00	NO PHYSICAL CHANGE
35	498	E249B	3.75	4.1	1:57	89.5	51:12	NO PHYSICAL CHANGE
30	520	D249B	3.74	5.5	1:33	106.0	107:48	NO PHYSICAL CHANGE
1	519	B249C	3.75	6.0	0:06	106.5	48:42	NO PHYSICAL CHANGE
34	516	B249A	3.75	6.0	0:36	110.5	109:18	NO PHYSICAL CHANGE
43	500	A249A	3.76	6.0	1:36	105.5	45:42	NO PHYSICAL CHANGE
29	519	C249B	3.73	5.6	0:06	106.5	114:30	NO PHYSICAL CHANGE
28	518	D249A	3.75	5.4	1:00	106.5	104:24	NO PHYSICAL CHANGE
								RTR# 90/014

Appendix F

Quality Control Department Destructive Analysis Reports
90-52-1 and 90-53-1

Quality Control Department Destructive Analysis Report 90 - 52 - 1

* *

Model: BCX149 DD Date Code: C249C-31 RGN: NA

Reason for DA: (FRESH) CELL WENT TO ϕ V ON 100 mΩ SHORT

OCV Without Fuse: BELOW* 20 Ω Load, Without Fuse: 0.00

Lead-to-Pin Weld: Undamaged (✓)

Crimp Weld: Undamaged (✓) Crimp Weld Not Required on this Model ( )

Anode-Lead-to-Case Welds: Undamaged (✓)

Examination of Anode Assembly:
NOT REQUIRED

Approximate Lithium Utilization: _____ %

Examination of Cathode Assembly:
NOT REQUIRED

Examination of Separators: Not Possible Due to Discharge ( )
NOT REQUIRED

Other Observations:
* OCV FLUCTUATED AROUND 3.5 V. CATHODE LEAD BURNED OUT BETWEEN CRIMP AND PIN. X-RAY TO S. MEYER. HOR, CATHODE LEAD TO C. FRYSZ.

Technician: B. Uelits Date: 22 FEB 90 Page 1 of 1

Dist: D. Sieminski ( ), S. Ebel ( ), R. Samit ( ), R. Neumann ( ), M. Pyszczek ( )
P. Krehl ( ), M. Zelinsky ( ), D. Spillman ( ), S. MEYER , _____

Quality Control Department Destructive Analysis Report 90 - 53 - 1

* *

Model: BCX149 DD Date Code: A2998-32 RGN: NA

Reason for DA: (FRESH) CELL WENT TO ϕ V ON 100 MΩ SHORT

OCV Without Fuse: BELOW* 20 Ω Load, Without Fuse: 0.00

Lead-to-Pin Weld: Undamaged (✓)

Crimp Weld: Undamaged (✓) Crimp Weld Not Required on this Model ( )

Anode-Lead-to-Case Welds: Undamaged (✓)

Examination of Anode Assembly:
NOT REQUIRED

Approximate Lithium Utilization: _____ %

Examination of Cathode Assembly:
NOT REQUIRED

Examination of Separators: Not Possible Due to Discharge ( )
NOT REQUIRED

Other Observations:
* OCV FLUCTUATED AROUND 3.5V. CATHODE LEAD BURNED OUT BETWEEN CRIMP AND PIN. X-RAY TO S. MEYER. HEADER, CATHODE LEAD TO C. FRYSZ.

Technician: B. Wolitz Date: 22 FEB 90 Page 1 of 1

Dist: D. Sieminski ( ), S. Ebel ( ), R. Samit ( ), R. Neumann ( ), M. Pyszczek ( )
P. Krehl ( ), M. Zelinsky ( ), D. Spillman ( ), S. MEYER

Appendix G

Charging Test Report 90-013

RELIABILITY TEST RESULTS

MODEL: BCX149DD (3B2085-XA)	DATE: 21FEB90	REPORT NO: 90/013

TEST: CHARGE (REF: NAS9-18142)

ORIGINATOR: S. Meyer (REF: E.I/TR#89-111)

PURPOSE:

The purpose of these tests is to satisfy the requirements as stated in NASA Contract NAS9-18142, Section C (statement of work), Item D Task 4 (cell abuse tests), Para 2 (charging tests).

PARAMETERS:

Charging tests are to be performed on ten cells each of both fresh and discharged units at three different charging rates. Charging rates of 350mA, 1A and 3.5A were used. A total of 60 cells were tested. Charging times corresponding to rate were as follows:

Rate	Time (Min)
350 mA	96 Hrs
1A	24 Hrs
3.5A	5 Hrs

Voltage required to push the desired current was attained by adjusting the power source. The voltages are included in the test tables.

All fresh cells not destroyed by these tests were returned and discharged at room temperature under a 10 ohm load.

RESULTS:

See Figures 1 - 6

Figure 1 - Fresh Cells at 350mA
Figure 2 - Fresh Cells at 1A
Figure 3 - Fresh Cells at 3.5A
Figure 4 - Discharged Cells at 350mA
Figure 5 - Discharged Cells at 1A
Figure 6 - Discharged Cells at 3.5A

NOTE: All fresh cells which were charged at the 3.5 ampere rate ruptured as a result of the test.

SUBMITTED BY: T. Thrasher	DATE: 26FEB90
APPROVED BY: R. C. Smith	DATE: 26 Feb 90
DISTRIBUTION: S. Meyer, E. Takeuchi, W. Clark	PAGE 1 OF 11

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 1
FRESH CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	OCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
46/C249B	3.88	10	350	33.5	98:16	NO PHYSICAL CHANGE
10/B249A	3.87	10	350	34.0	90:30	NO PHYSICAL CHANGE
22/A249A	3.88	10	350	37.5	91:00	NO PHYSICAL CHANGE
18/C249C	3.83	10	350	30.5	98:09	NO PHYSICAL CHANGE
29/D249B	3.79	10	350	30.0	111:34	NO PHYSICAL CHANGE
41/A299A	3.92	10	350	26.0	97:24	NO PHYSICAL CHANGE
12/B249C	3.89	10	350	33.0	97:18	NO PHYSICAL CHANGE
24/A299B	3.92	10	350	32.5	97:00	NO PHYSICAL CHANGE
46/D249C	3.78	10	350	25.0	98:08	NO PHYSICAL CHANGE
6/D249A	3.78	10	350	27.5	103:12	NO PHYSICAL CHANGE

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 2
FRESH CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	OCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
4/A299A	3.92	15	1000	42.0	66:24	NO PHYSICAL CHANGE
23/B249A	3.87	15	1000	50.5	23:53	NO PHYSICAL CHANGE
5/B249C	3.88	15	1000	49.0	24:48	NO PHYSICAL CHANGE
42/E249B	3.79	15	1000	43.0	28:12	NO PHYSICAL CHANGE
35/E249A	3.79	15	1000	43.0	25:38	NO PHYSICAL CHANGE
30/D299C	3.79	15	1000	52.0	24:04	NO PHYSICAL CHANGE
25/D249B	3.78	15	1000	49.5	24:04	NO PHYSICAL CHANGE
38/A249B	3.92	15	1000	46.5	24:03	NO PHYSICAL CHANGE
8/D249A	3.85	15	1000	49.5	24:56	NO PHYSICAL CHANGE
40/A299B	UNAVAILABLE FOR TEST - CELL INADVERTENTLY DISPOSED OF					

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 3
FRESH CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	OCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
5/A299B	3.90	20	3500	81.0	1:42	CASE RUPTURE AT 1:42
42/A299A	3.91	20	3500	73.5	1:31	CASE RUPTURE AT 1:31
15/A249A	3.92	20	3500	94.0	4:44	CASE RUPTURE AT 4:44
45/B249B	3.89	20	3500	85.0	0:50	CASE RUPTURE AT 0:50
15/C249B	3.87	20	3500	92.0	1:08	CASE RUPTURE AT 1:08
46/E249B	3.81	20	3500	82.5	0:45	VENT THROUGH GLASS SEAL AND CASE AT 0:45
24/C249C	3.87	20	3500	91.0	0:48	CASE RUPTURE AT 0:48
19/D249C	3.84	20	3500	83.0	0:36	CASE RUPTURE AT 0:36
32/B249C	3.90	20	3500	83.5	1:58	CASE RUPTURE AT 1:58
12/E249A	3.81	20	3500	77.5	1:03	CASE RUPTURE AT 1:03

TEST REQUEST # E.I/TR# 89-111

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FIGURE 4
DISCHARGED CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	CCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
48/B249C	3.63	10	350	27.5	97:21	NO PHYSICAL CHANGE
4/E249A	3.64	10	350	25.0	140:48	NO PHYSICAL CHANGE
13/D249A	3.59	10	350	29.5	97:00	NO PHYSICAL CHANGE
44/E249A	3.62	10	350	31.0	113:42	NO PHYSICAL CHANGE
2/E249A	0.00	10	350	25.5	99:33	NO PHYSICAL CHANGE
26/A249B	3.65	20	350	26.0	96:03	NO PHYSICAL CHANGE
15/D249B	3.65	15	350	25.0	98:54	NO PHYSICAL CHANGE
11/D249A	0.01	10	350	24.0	99:00	NO PHYSICAL CHANGE
15/E249B	3.66	10	350	28.5	139:48	NO PHYSICAL CHANGE

NOTE: TENTH CELL WAS DESIGNATED FOR DESTRUCTIVE ANALYSIS DUE TO POOR DISCHARGE CHARACTERISTICS. REFERENCE SEPARATE DA REPORT BY B. WEBESTER

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. Parker, D. Crossley

FIGURE 5
DISCHARGED CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	OCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
34/D249B	0.01	20	1000	40.5	64:00	NO PHYSICAL CHANGE
22/B249A	3.66	20	1000	39.0	64:24	NO PHYSICAL CHANGE
32/A299A	3.61	20	1000	43.0	24:03	NO PHYSICAL CHANGE
25/B249C	0:01	20	1000	42.0	58:30	NO PHYSICAL CHANGE
24/D249B	0:01	20	1000	46.5	58:15	NO PHYSICAL CHANGE
12/A299A	3.61	20	1000	45.5	24:09	NO PHYSICAL CHANGE
21/B249B	3.64	20	1000	45.5	24:15	NO PHYSICAL CHANGE
46/D249B	3.58	20	1000	46.5	24:00	NO PHYSICAL CHANGE
5/A299A	3.63	20	1000	40.0	24:00	NO PHYSICAL CHANGE
19/A249B	3.58	20	1000	38.5	24:03	NO PHYSICAL CHANGE

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PERFORMED BY L. Parker, D. Crossley

FIGURE 6
DISCHARGED CELLS
RECHARGE (CHARGE) TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R&D)

SERIAL NUMBER & DATE CODE	OCV BEFORE TEST	POWER SUPPLY		PEAK TEMP (°)	TEST TIME (Hr:Min)	RESULTS
		RECHARGE VOLTAGE (V)	RECHARGE CURRENT (mA)			
31/D249A	3.50	20	3500	75.0	6:37	NO PHYSICAL CHANGE
10/C249B	3.61	20	3500	86.0	5:16	NO PHYSICAL CHANGE
26/D249B	3.64	20	3500	86.0	5:06	NO PHYSICAL CHANGE
17/D249C	3.57	20	3500	89.0	5:03	NO PHYSICAL CHANGE
30/B249A	3.62	20	3500	80.0	5:01	NO PHYSICAL CHANGE
43/D249B	3.61	20	3500	95.0	5:28	NO PHYSICAL CHANGE
10/D249C	0.01	20	3500	84.0	5:05	NO PHYSICAL CHANGE
32/B249B	3.64	20	3500	82.5	5:01	NO PHYSICAL CHANGE
32/D249A	3.66	20	3500	55.0	0:23	VIOLENT VENT THROUGH GLASS SEAL, SIDE OF CASE DENTED AND HEAT STAINED
7/A299A	3.67	20	3500	90.0	5:02	NO PHYSICAL CHANGE

Appendix H

Overdischarge Test Report 90-016

WG

RELIABILITY TEST RESULTS

MODEL: BCX149DD (3B2085-XA)	DATE: 30MAY90	REPORT NO: 90/044
TEST: OVERDISCHARGE		

ORIGINATOR: S. Meyer (REF: E.I/TR#89-111)

PURPOSE: The purpose of these tests is to satisfy the requirements as stated in NASA Contract NAS9-18142, Section C (statement of work), Item D Task 4 (cell abuse tests), Para 3 (overdischarge tests).

PARAMETERS: Overdischarge testing shall be performed on a minium of 10 cells per test condition over as many as three rates, two temperatures, with and without protective diodes. Also a minimum of 10 cells per test condition over the three rates, two temperatures are to be tested with out diodes only. All tests are to be run for a minimum of 16 hours.

Rates to be tested include 350 mA, 2 amperes, and 5 amperes. Test temperatures are to be room temperature ambient and 71°C. A total of 120 cells are to be tested over 180, sixteen hour test regimes. The cells tested have come from the performance testing (task 3) and are all EOL units.

Cell voltage, power source current and skin temperature were monitored and recorded.

RESULTS:
See Figures 1 - 18 (10 cells each test for a total of 120 cells)

Figure 1 - 350mA at Room Temperature without diodes only
Figure 2 - 2A at Room Temperature without diodes only
Figure 3 - 5A at Room Temperature without diodes only
Figure 4 - 350mA at 71°C without diodes only
Figure 5 - 2A at 71°C without diodes only
Figure 6 - 5A at 71°C without diodes only
Figure 7 - 350mA at Room Temperature with diode
Figure 8 - 350mA at Room Temperature without diode
Figure 9 - 2A at Room Temperature with diode
Figure 10 - 2A at Room Temperature without diode
Figure 11 - 5A at Room Temperature with diode
Figure 12 - 5A at Room Temperature without diode
Figure 13 - 350mA at 71°C with diode
Figure 14 - 350mA at 71°C without diode
Figure 15 - 2A at 71°C with diode
Figure 16 - 2A at 71°C without diode
Figure 17 - 5A at 71°C with diode
Figure 18 - 5A at 71°C without diode

NOTE: For Figures 7 - 18 the same ten cells were used to test both the with diode and without diode test results (total of 60 cells).

SUBMITTED BY:	DATE: 31 MAY90
APPROVED BY:	DATE:
DISTRIBUTION: S. Meyer, E. Takeuchi, W. Clark	PAGE: 1 OF 1

FORM NO. 7044/0783 "REV A"

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 1: 350mA AT ROOM TEMPERATURE
WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
19/D249A	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
27/D249B	3.61	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
2/B249A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
17/D249B	3.66	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
7/A299B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
39/D249C	3.63	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
5/A249A	3.30	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
23/A299A	3.63	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
16/A299B	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
31/A249A	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
				RTR# 90/044

C-3

TEST REQUEST # E.I/TR# 89-111

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FIGURE 2: 2A AT ROOM TEMPERATURE
WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
24/E249A	3.59	86.0	16:06	SMALL HEAT STAIN ON CASE NO VENT OR RUPTURE
12/A249A	3.64	42.5	0:30	NO PHYSICAL CHANGE
37/E249A	3.66	65.5	1:15	NO PHYSICAL CHANGE
14/B249C	3.56	93.5	4:48	SMALL HEAT STAIN ON CASE NO VENT OR RUPTURE
29/E249A	3.66	40.5	0:27	NO PHYSICAL CHANGE
18/D249A	3.66	51.5	0:42	NO PHYSICAL CHANGE
10/C249C	0.01	63.0	15:36	NO PHYSICAL CHANGE
6/A299B	3.18	75.0	4:12	NO PHYSICAL CHANGE
47/C249C	0.01	67.5	16:09	NO PHYSICAL CHANGE
24/A249B	3.67	53.5	0:42	NO PHYSICAL CHANGE
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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 3: 5A AT ROOM TEMPERATURE WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
23/E249A	0.01	128.0	1:45	VENT THROUGH GLASS SEAL, CASE BULGED
2/C249B	0.01	137.0	1:12	NO VENT OR RUPTURE, SMALL HEAT STAIN ON CASE, CASE BULGED
46/E249A	3.66	202.0 >250.0*	12:00 2:40*	NO VENT OR RUPTURE, LARGE HEAT STAIN ON CASE, CASE BULGED
21/B249C	3.66	72.5	0:27	NO PHYSICAL CHANGE
42/B249B	3.63	225.0 >250.0*	3:33 3:09*	NO VENT OR RUPTURE, LARGE HEAT STAIN ON CASE, CASE BULGED
21/D249B	3.59	181.0	2:06	NO VENT OR RUPTURE, CASE HEAT STAINED AND BULGED
47/D249C	3.49	176.0	0:34	NO VENT OR RUPTURE, CASE HEAT STAINED AND BULGED
47/B249C	3.64	63.0	0:27	NO PHYSICAL CHANGE
26/E249A	0.01	172.5	1:18	VENT THROUGH GLASS SEAL, CASE BULGED
13/A299B	0.01	STRIP CHART RECORDER MALFUNCTIONED		VENT THROUGH GLASS SEAL, CASE BULGED

*TEMPERATURE SPIKE

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 4: 350mA AT 71°C WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
9/D249A	3.66	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
28/C249C	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
11/B249A	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
36/C249C	3.56	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
41/A299B	3.63	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
43/E249A	3.46	209.0*	6:12*	NO VENT OR RUPTURE HEAT STAIN ON CASE
33/D249C	3.66	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
28/E249B	3.60	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
39/E249B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
30/C249B	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
		*TEMPERATURE SPIKE		RTR# 90/044 PAGE 5 OF 19

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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 5: 2A AT 71°C WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
13/D249B	3.29	115.0	1:42	NO VENT OR RUPTURE CASE BULGED
16/A249B	3.64	152.0	1:24	NO VENT OR RUPTURE, CASE HEAT STAINED & BULGED
14/A249A	0.57	114.5	5:16	NO VENT OR RUPTURE CASE BULGED
45/E249A	3.59	156.0	0:54	NO VENT OR RUPTURE CASE BULGED
24/C249B	3.66	117.5 178.5*	12:48 15:24*	NO VENT OR RUPTURE, CASE HEAT STAINED &BULGED
4/A299B	3.61	118.0	4:42	NO VENT OR RUPTURE CASE BULGED
32/D249B	3.61	STRIP CHART RECORDER MALFUNCTIONED		NO VENT OR RUPTURE, SMALL HEAT STAIN ON CASE, CASE BULGED
15/A299B	3.52	120.0	0:48	NO VENT OR RUPTURE CASE BULGED
35/A249A	3.65	139.0	14:30	NO VENT OR RUPTURE, CASE HEAT STAINED & BULGED
39/D249A	3.63	130.0	1:27	NO VENT OR RUPTURE, CASE BULGED
		*TEMPERATURE SPIKE		RTR# 90/044 PAGE 6 OF 19

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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 6: 5A AT 71°C WITHOUT DIODE ONLY

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
1/D249A	3.65	162.0	1:12	NO VENT OR RUPTURE CASE BULGED
40/A249B	0.01	79.5	7:18	NO PHYSICAL CHANGE
18/D249C	0.01	203.5	0:42	CELL VENTED THROUGH GLASS SEAL, CASE HEAT STAINED & BULGED
20/A299A	0.01	202.5	1:12	CELL VENTED THROUGH GLASS SEAL, CASE HEAT STAINED & BULGED
45/B249A	3.58	205.0	1:24	CELL VENTED THROUGH GLASS SEAL, CASE HEAT STAINED & BULGED
7/A249A	3.46	187.0	0:30	CELL VENTED THROUGH GLASS SEAL, CASE HEAT STAINED & BULGED
17/B249C	3.67	IMMEDIATE LOSS OF COMPLETE INTERNAL CONTINUITY		
29/A299B	3.67	IMMEDIATE LOSS OF COMPLETE INTERNAL CONTINUITY		
17/C249C	3.64	159.5 >250.0*	0:20 6:30*	NO VENT OR RUPTURE, CASE BULGED
9/B249C	3.63	154.5	6:41	NO VENT OR RUPTURE, CASE BULGED
		*TEMPERATURE SPIKE		RTR# 90/044 PAGE 7 OF 19

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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 7: 350mA AT ROOM TEMPERATURE WITH DIODE

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
23/D249C	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
26/C249C	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
42/E249A	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
15/B249A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
7/B249C	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
34/D249A	3.64	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
48/C249C	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
35/A299A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
14/C249C	3.66	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
9/C249C	3.42	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
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FIGURE 8: 350mA AT ROOM TEMPERATURE WITHOUT DIODE

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

PERFORMED BY L. PARKER, D. CROSSLEY

FORCE-OVERDISCHARGE TEST

PREVIOUSLY TESTED WITH DIODES

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
23/D249C	3.57	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
26/C249C	0.04	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
42/E249A	3.58	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
15/B249A	0.00	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
7/B249C	0.02	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
34/D249A	0.12	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
48/C249C	0.03	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
35/A299A	0.00	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
14/C249C	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
9/C249C	0.58	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 9: 2A AT ROOM TEMPERATURE WITH DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
34/A299A	3.55	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
17/A299B	3.64	56.0	0:35	NO PHYSICAL CHANGE
14/D249C	3.66	47.0	0:30	NO PHYSICAL CHANGE
1/D249C	3.61	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
23/A299B	3.62	35.0	0:30	NO PHYSICAL CHANGE
8/A299A	3.62	33.5	0:03	NO PHYSICAL CHANGE
47/A299A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
12/D249C	3.66	45.5	0:30	NO PHYSICAL CHANGE
4/D249B	3.64	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
37/A299B	3.65	42.5	0:16	NO PHYSICAL CHANGE
				RTR# 90/044 PAGE 10 OF 19

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FIGURE 10: 2A AT ROOM TEMPERATURE WITHOUT DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

PERFORMED BY L. PARKER, D. CROSSLEY

PREVIOUSLY TESTED WITH DIODES

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
34/A299A	0.02	95.0	2:57	NO VENT OR RUPTURE SMALL HEAT STAIN ON CASE
17/A299B	3.58	91.0	15:21	NO PHYSICAL CHANGE
14/D249C	3.62	36.5	0:06	NO PHYSICAL CHANGE
1/D249C	3.44	63.0 175.5*	5:10 6:00*	NO VENT OR RUPTURE, LARGE HEAT STAIN ON CASE, CASE BULGED
23/A299B	3.44	76.5	6:30	NO VENT OR RUPTURE SMALL HEAT STAIN ON CASE
8/A299A	3.59	85.0	8:24	NO VENT OR RUPTURE, SMALL HEAT STAIN ON CASE
47/A299A	0.01	93.5	2:24	NO PHYSICAL CHANGE
12/D249C	1.37	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
4/D249B	3.63	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
37/A299B	3.57	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
		*TEMPERATURE SPIKE		RTR# 90/044 PAGE 11 OF 19

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 11: 5A AT ROOM TEMPERATURE WITH DIODE

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
3/D249B	3.63	47.0	0:51	NO PHYSICAL CHANGE
45/D249B	3.67	75.0	0:42	NO PHYSICAL CHANGE
4/D249C	3.60	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
24/A249A	3.61	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
43/C249C	3.64	51.0	0:21	NO PHYSICAL CHANGE
22/A299B	3.66	38.0	0:18	NO PHYSICAL CHANGE
20/A299B	3.64	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
16/B249B	3.38	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
9/D249B	3.56	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
39/B249A	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
				RTR# 90/044 PAGE 12 OF 19

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

PREVIOUSLY TESTED WITH DIODES

FIGURE 12: 5A AT ROOM TEMPERATURE WITHOUT DIODE

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
3/D249B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
45/D249B	3.23	36.5	0:27	NO PHYSICAL CHANGE
4/D249C	3.51	160.5	0:30	NO VENT OR RUPTURE, SMALL HEAT STAIN ON CASE, CASE BULGED
24/A249A	3.51	73.0 181.0*	0:15 3:36*	NO VENT OR RUPTURE, SIDE OF CASE HEAT STAINED & BULGED
43/C249C	3.15	111.0	3:57	NO VENT OR RUPTURE CASE BULGED
22/A299B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
20/A299B	0.01	39.0	1:30	NO PHYSICAL CHANGE
16/B249B	0.18	175.0	1:18	NO VENT OR RUPTURE, SIDE OF CASE HEAT STAINED & BULGED
9/D249B	3.52	147.5	0:15	LOSS OF INTERNAL CONTINUITY 15 MIN AFTER START OF TEST. CASE HEAT STAINED & BULGED
39/B249A	0.02	114.5	2:33	NO VENT OR RUPTURE, LARGE HEAT STAIN ON CASE, CASE BULGED
		*TEMPERATURE SPIKE		

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 13: 350mA AT 71°C WITH DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
4/A249B	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
21/C249C	3.58	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
31/E249A	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
13/D299C	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
10/A299A	3.64	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
22/C249C	3.51	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
40/E249A	3.65	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
22/D249C	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHAN GE
28/A299A	3.62	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
31/B249B	3.58	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
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TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

PREVIOUSLY TESTED WITH DIODES

FIGURE 14: 350mA AT 71°C WITHOUT DIODE

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
4/A249B	3.27	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
21/C249C	0.05	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
31/E249A	3.03	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
13/D299C	0.00	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
10/A299A	3.31	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
22/C249C	0.00	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
40/E249A	3.31	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
22/D249C	3.15	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHAN GE
28/A299A	3.60	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
31/B249B	3.48	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 15: 2A AT 71°C WITH DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
39/B249C	3.61	89.0	0:18	NO PHYSICAL CHANGE
34/A299B	3.66	107.0	0:36	NO PHYSICAL CHANGE
9/D249C	3.67	116.5	2:00	NO PHYSICAL CHANGE
41/E249A	3.61	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
18/E249B	0.00	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
8/D249C	3.62	86.5	0:24	NO PHYSICAL CHANGE
48/B249A	3.63	93.5	0:30	NO PHYSICAL CHANGE
43/A299A	3.66	112.0	0:42	NO PHYSICAL CHAN GE
11/C249C	3.66	111.0	0:42	NO PHYSICAL CHANGE
44/D249B	3.66	119.0	1:12	NO PHYSICAL CHANGE
				RTR# 90/044

TEST REQUEST # E.I/TR# 89-111

PERFORMED BY L. PARKER, D. CROSSLEY

PREVIOUSLY TESTED WITH DIODES

FIGURE 16: 2A AT 71°C WITHOUT DIODE

FORCE-OVERDISCHARGE TEST

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
39/B249C	0.01	120.5	1:10	NO VENT OR RUPTURE CASE BULGED
34/A299B	0.61	79.0	0:29	NO VENT OR RUPTURE CASE BULGED
9/D249C	0.00	78.5	1:19	NO VENT OR RUPTURE CASE BULGED
41/E249A	0.30	162.5	1:08	NO VENT OR RUPTURE CASE BULGED
18/E249B	0.00	126.0	6:42	NO VENT OR RUPTURE CASE BULGED
8/D249C	3.51	114.5	1:12	NO PHYSICAL CHANGE
48/B249A	0.78	116.5	2:46	NO PHYSICAL CHANGE
43/A299A	3.42	100.0 >250.0*	0:44 11:26*	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
11/C249C	3.42	121.5 >250.0*	8:36 8:37*	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
44/D249B	3.42	109.0	20:39	NO VENT OR RUPTURE CASE BULGED
		*TEMPERATURE SPIKE		RTR# 90/044 PAGE 17 OF 19

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PERFORMED BY L. PARKER, D. CROSSLEY

FIGURE 17: 5A AT 71°CWITH DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
26/D249A	3.60	134.0	0:21	NO PHYSICAL CHANGE
11/B249B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
39/A299A	3.65	107.0	0:33	NO PHYSICAL CHANGE
44/B249B	3.58	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
36/D249A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
34/A249B	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
17/D249A	0.05	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
43/A299B	3.67	139.0	0:48	NO PHYSICAL CHANGE
3/A299A	3.66	116.0	0:30	NO PHYSICAL CHANGE
31/B249C	3.59	99.0	0:15	NO PHYSICAL CHANGE
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TEST REQUEST # E.I/TR# 89-111

FIGURE 18: 5A AT 71°C WITHOUT DIODE

FORCE-OVERDISCHARGE TEST

☐ COMMERICAL
☐ MEDICAL
☒ OTHER (R &D)

PERFORMED BY L. PARKER, D. CROSSLEY

PREVIOUSLY TESTED WITH DIODES

MODEL BCX149DD (3B2085-XA) CHEMISTRY Li/BCX

SERIAL NUMBER AND DATE CODE	OCV BEFORE TEST	PEAK TEMP (°C)	TIME TO PEAK TEMP (Hr:Min)	RESULTS
26/D249A	0.01	225.0	0:30	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
11/B249B	0.00	237.0	1:06	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
39/A299A	3.58	157.5	3:09	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
44/B249B	0.01	168.5	0:27	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
36/D249A	0.00	153.5	1:06	NO VENT OR RUPTURE CASE BULGED
34/A249B	0.00	181.0	1:51	VENT THROUGH GLASS SEAL CASE BULGED
17/D249A	0.01	NO SIGNIFICANT TEMPERATURE RISE		NO PHYSICAL CHANGE
43/A299B	0.62	180.5	0:42	VIOLENT RUPTURE OCCURRED 42 MIN AFTER START OF TEST
3/A299A	3.62	149.0	0:24	NO VENT OR RUPTURE, SMALL HEAT STAIN ON CASE, CASE BULGED
31/B249C	0.01	157.0	1:57	NO VENT OR RUPTURE CASE HEAT STAINED & BULGED
				RTR# 90/044 PAGE 19 OF 19

Appendix I

MGA Research Corporation Shock and Vibration Test Report

mga research corporation

October 11, 1989

Wilson Greatbatch, Ltd.
10,000 Wehrle Drive
Clarence, New York 14031

Ref: MGA File No.: C89E-02.20

Attention: Mr. T. Umphreyville

Dear Tom:

Enclosed please find the test report for the shock and vibration testing conducted on (20) model BCX149DD cells.

The shock test was conducted with peak acceleration equal to 200 g's and the duration equal to 0.5 milliseconds. The shock was applied in two directions along each of the three mutually perpendicular axes for a total of six shocks.

The random vibration test was conducted at three different levels - 17.6 GRMS, 20.1 GRMS, and 24.9 GRMS. The vibration was applied for 15 minutes/axis at each of the three levels.

If you have any questions, or require additional infomation, please let me know.

Best regards,

MGA Research Corporation

Robert M. Willadsen

RMW/ej
Enc.

• 12790 main road • p.o. box 71 • akron, new york 14001-0071 • 716/542-5515 • fax 716/542-4437 •

TEST SUMMARY DATA

Tests Conducted:	Shock and Vibration
Tests Conducted:	Wilson Greatbatch, Ltd.
Client Order No.:	23707
Test Specifications:	Shock - 200 G's for 0.5 in two directions along each of (3) mutually perpendicular axes. Vibration - Level 1: 17.6 G's RMS Level 2: 20.1 G's RMS Level 3: 24.9 G's RMS Test articles were vibrated for 15 minutes/axis at each level indicated.
Test Specimen Data:	(20) BCX149DD Cells S/N: 22, 32, 27, 18, A299B3, 19, 37, 8, 7, D299A3 Subjected to Shock Test S/N: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34 Subjected to Vibration Test
Date Test Completed:	September 29, 1989
Test Results:	No physical damage occurred to the cells as a result of the shock and vibration

3.0 TEST EQUIPMENT

ITEM	DESCRIPTION	MFG	MODEL	SERIAL NO.	CAL. DATE	DUE DATE
1	Accelerometer	PCB	302A02	11002	8/28/89	2/28/90
2	Signal Conditioner	PCB	482A	3453	8/28/89	2/28/89
3	Oscilloscope	HP	54200A	2511A	6/89	6/90
4	Drop Tower	MGA	G70	01	*	
5	Vibration System	U/D	SD11	-	8/28/89	2/28/90
6	Sweep Generator	Trig-Tek	701LM	424	8/28/89	2/28/90
7	Vibration Protector Monitor	Trig-Tek	620B	104	8/28/89	2/28/90
8	Compressor	Trig-Tek	801D	399	8/28/89	2/28/90
9	Multi Level	Trig-Tek	831A	185	8/28/89	2/20/90

*Calibrated before use

Wilson Greatbatch

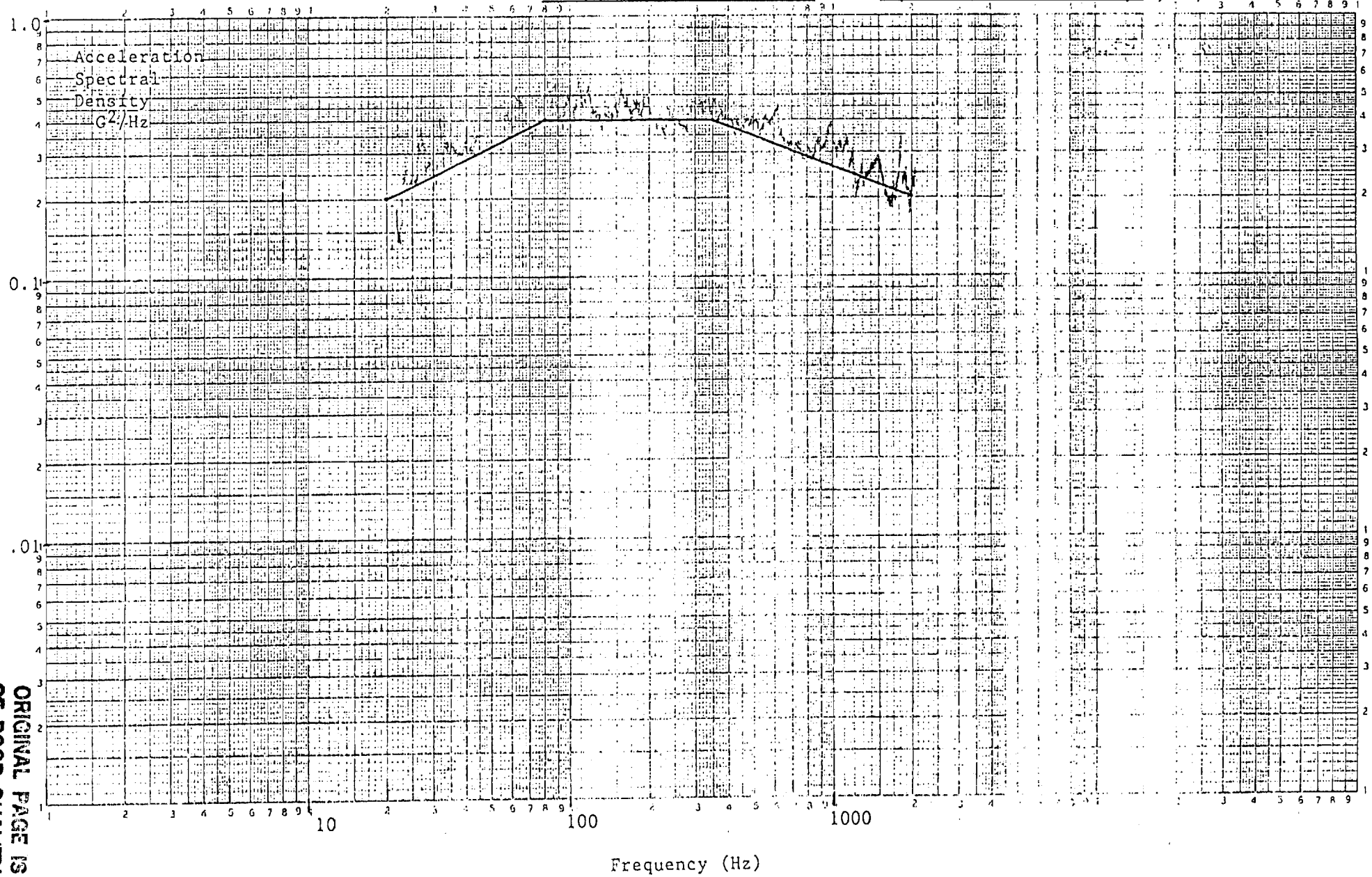
Axis: Transverse

Test Articles: (10) BCX1490 Overall G's RMS=24.9

Randon Vibration Test

Date: 9/29/89

S/N: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34



Wilson Greatbatch

Axis: Longitudinal

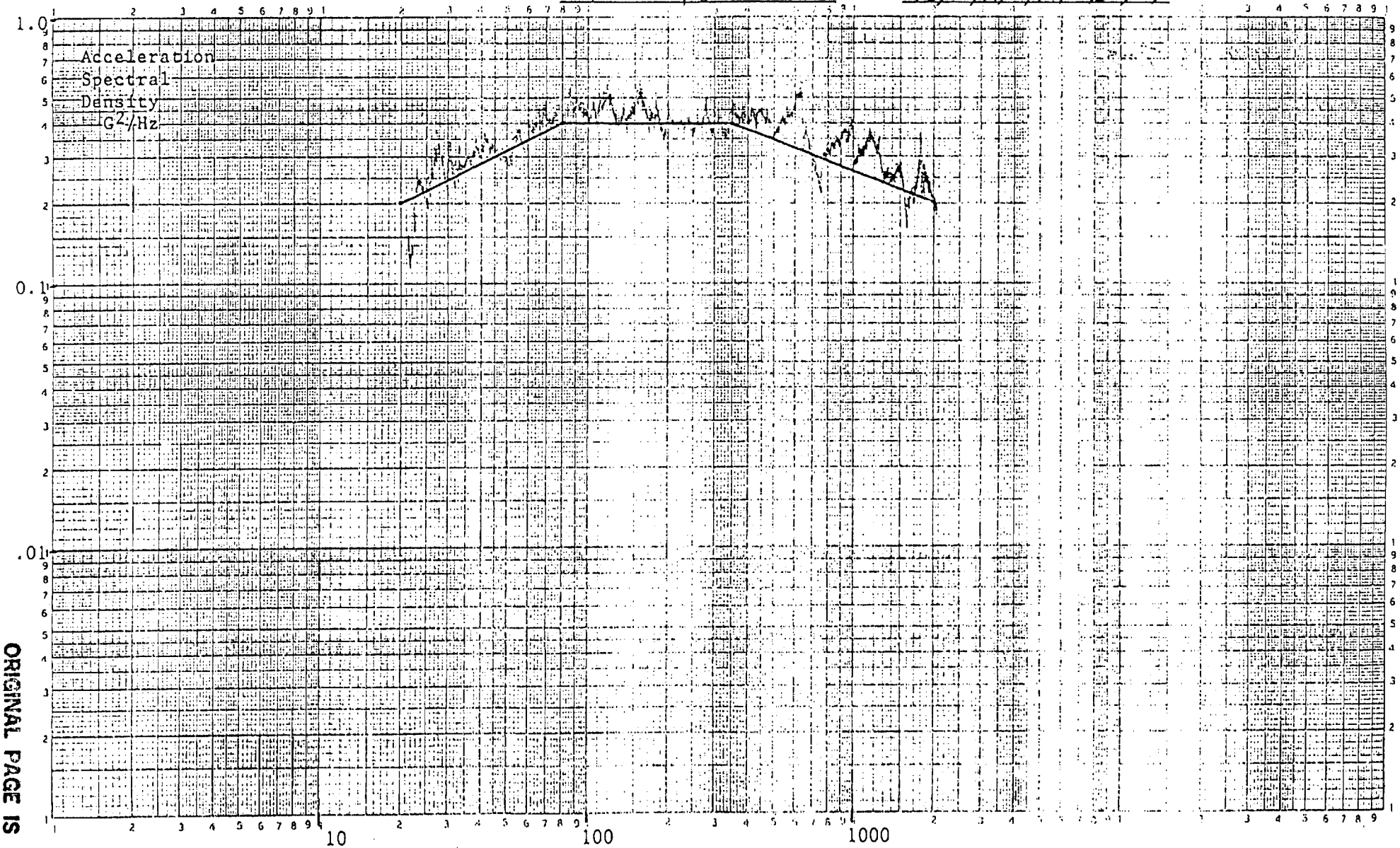
Test Articles: (10) BCX14900

Overall G's RMS=24.9

Randon Vibration Test

Date: 9/29/89

S/N: 48,35,14,21,44,26,30,18,12,34



APPENDIX A

TEST DATA SHEETS

Wilson Greatbatch

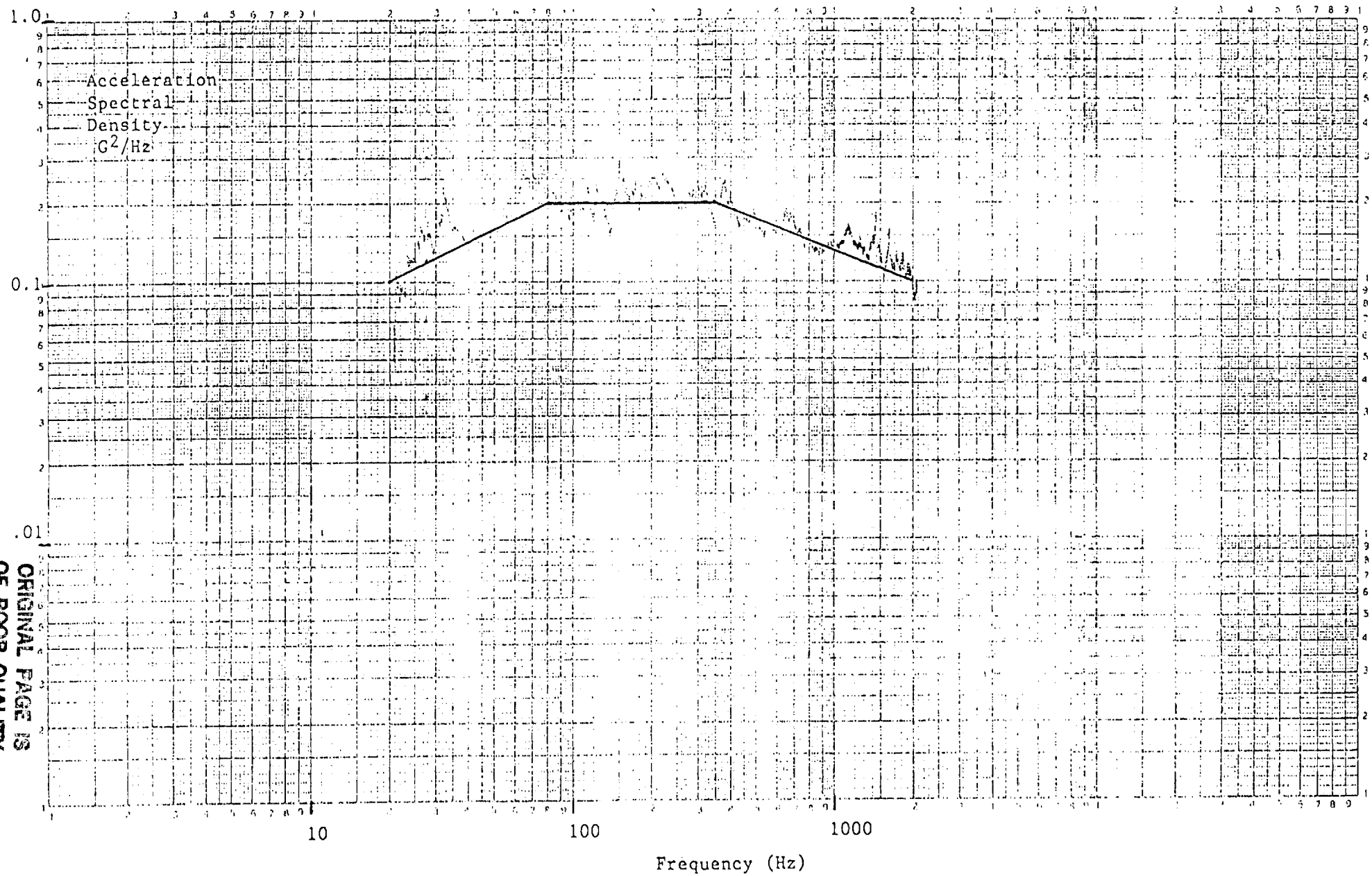
Random Vibration Test

Axis: Vertical

Date: 9/27/89

Test Articles: (10) BCx1400 Overall G's RMS=17.6

S/n: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34



Wilson Greatbatch

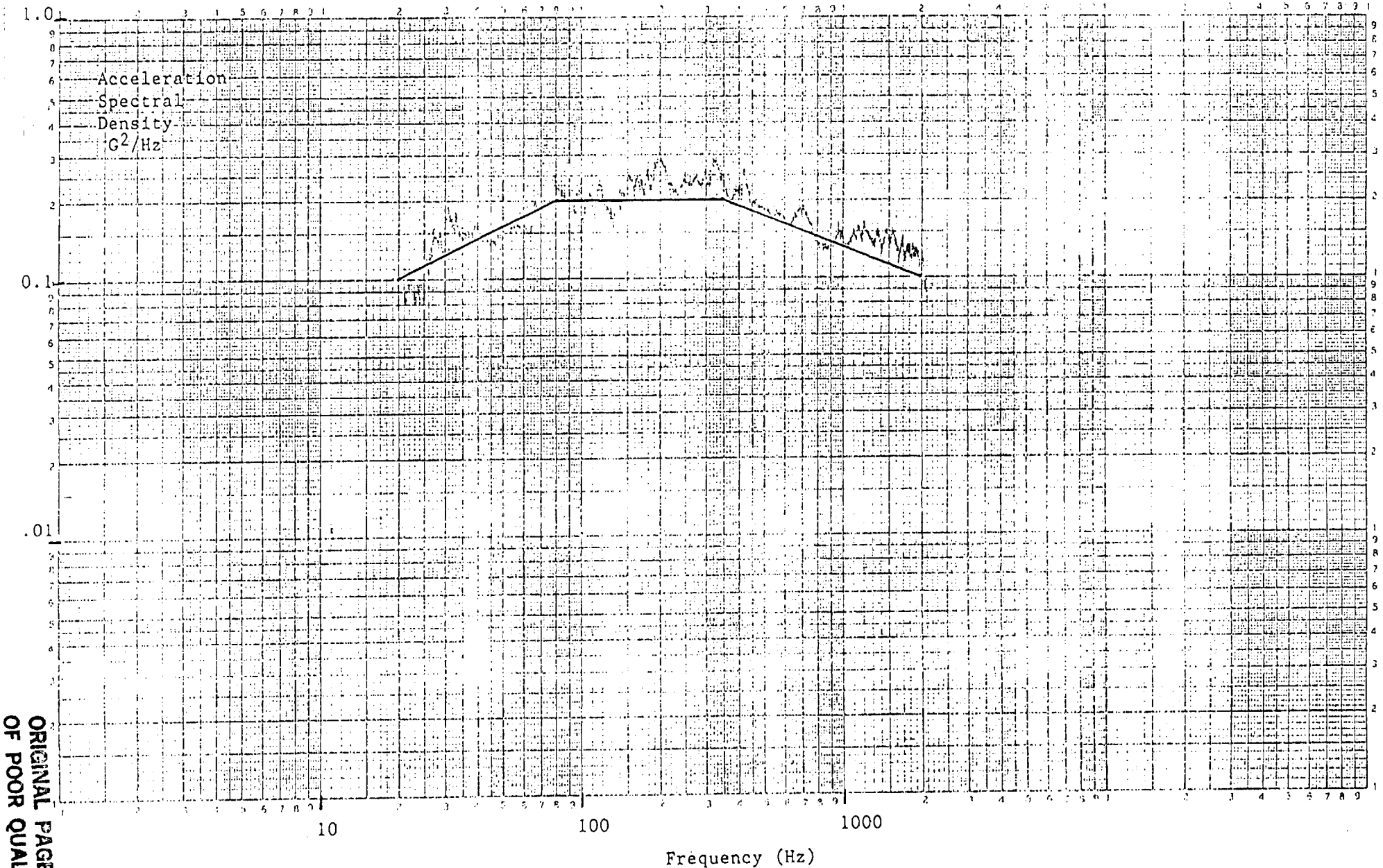
Random Vibration Test

Axis: Transverse

Date: 9/27/89

Test Articles: (10) BCX 1900 Overall G's RMS=17.6

S/n: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34



Wilson Greatbatch

Random Vibration Test

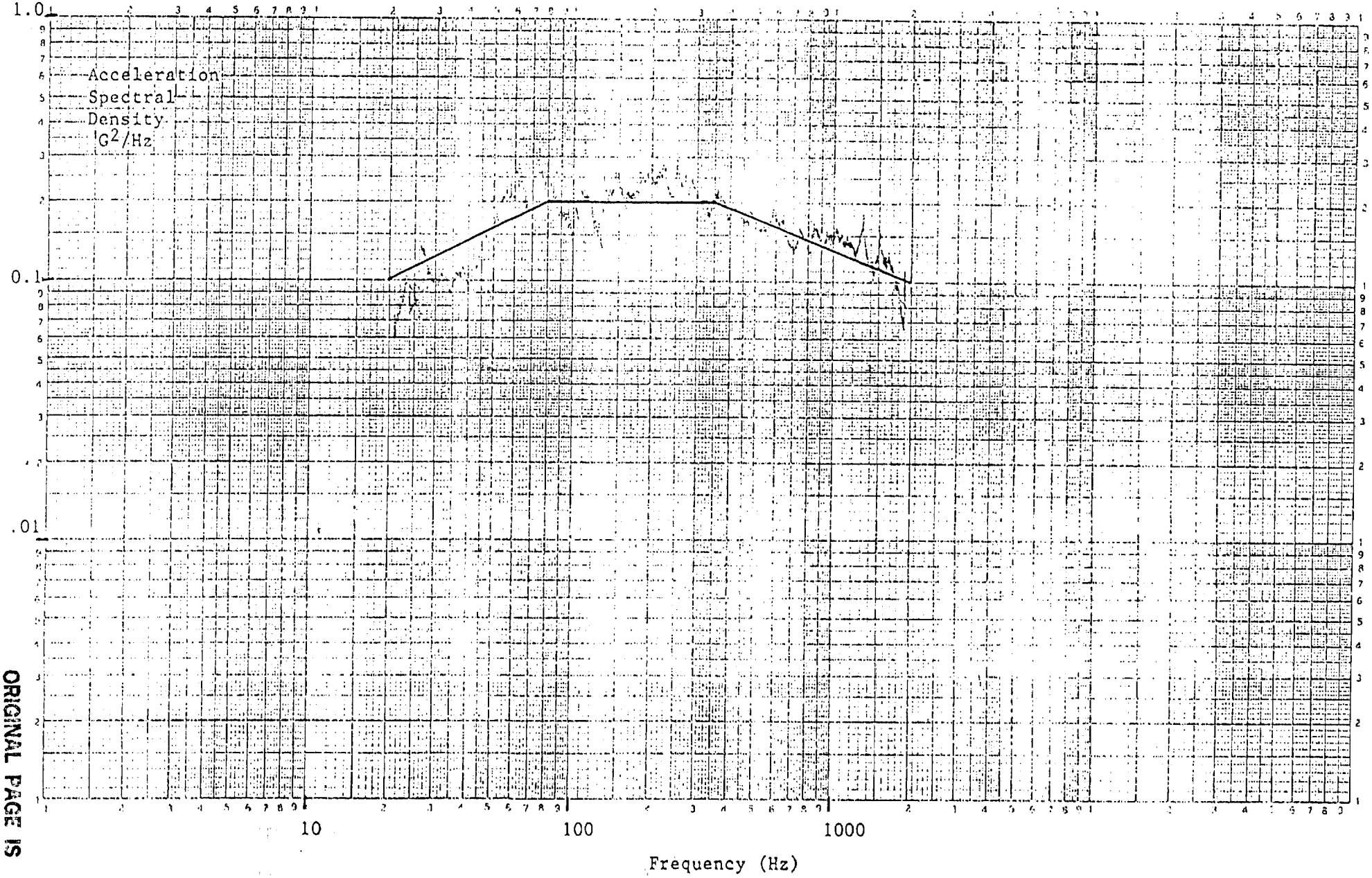
Axis: Longitudinal

Date: 9/27/89

Test Articles: (10) 8cx1490

Overall G's RMS=17.6

S/n: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34



Wilson Greatbatch

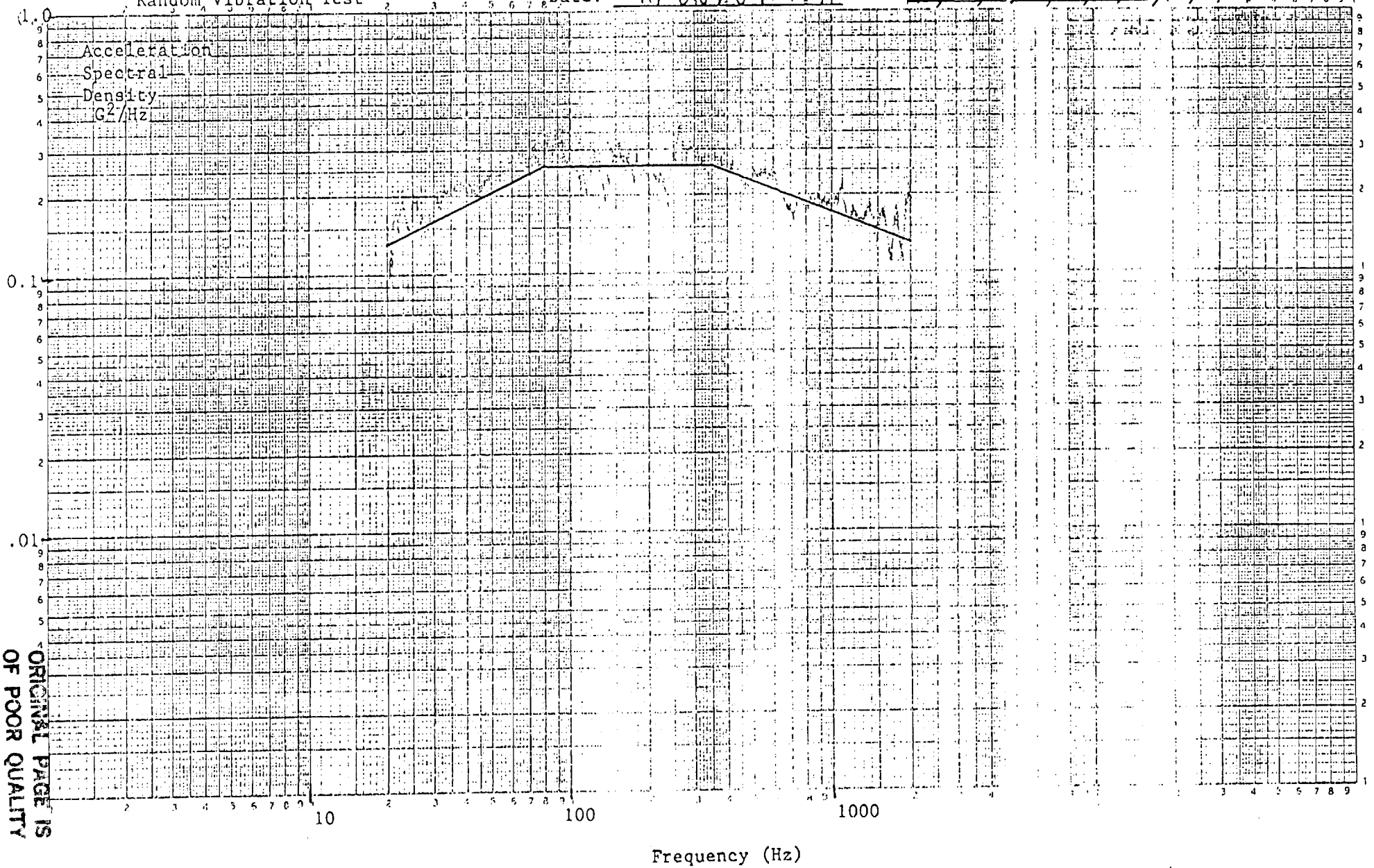
Axis: Vertical

Test Articles (10) BCx149.00 Overall G's RMS=20.1

Random Vibration Test

Date: 9/28/89

S/N: 48,35,14,21,44,26,30,18,12,34



Wilson Greatbatch

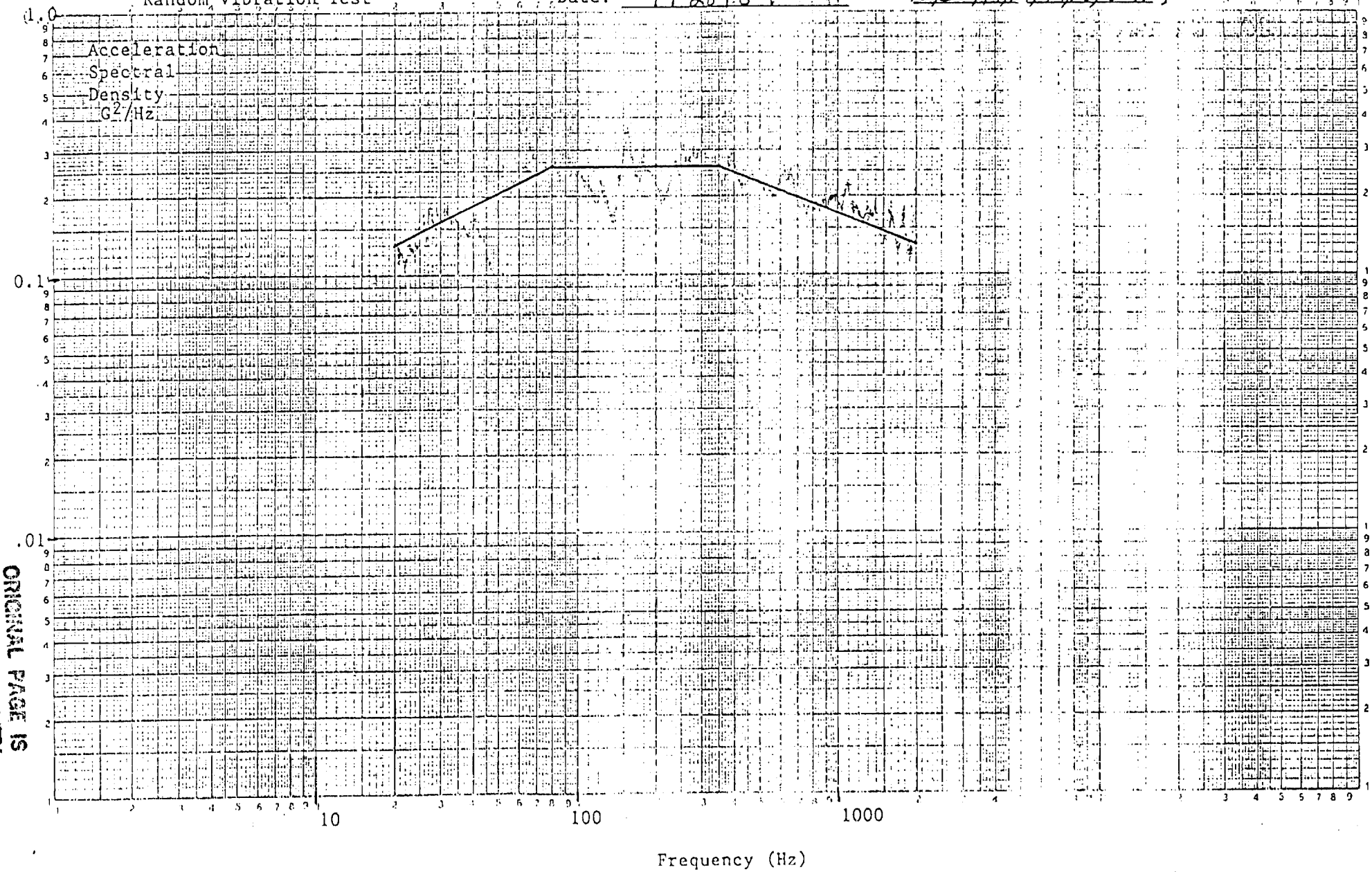
Axis: Transverse

Test Articles (10) BCX 14900 Overall G's RMS=20.1

Random Vibration Test

Date: 9/28/89

S/N: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34

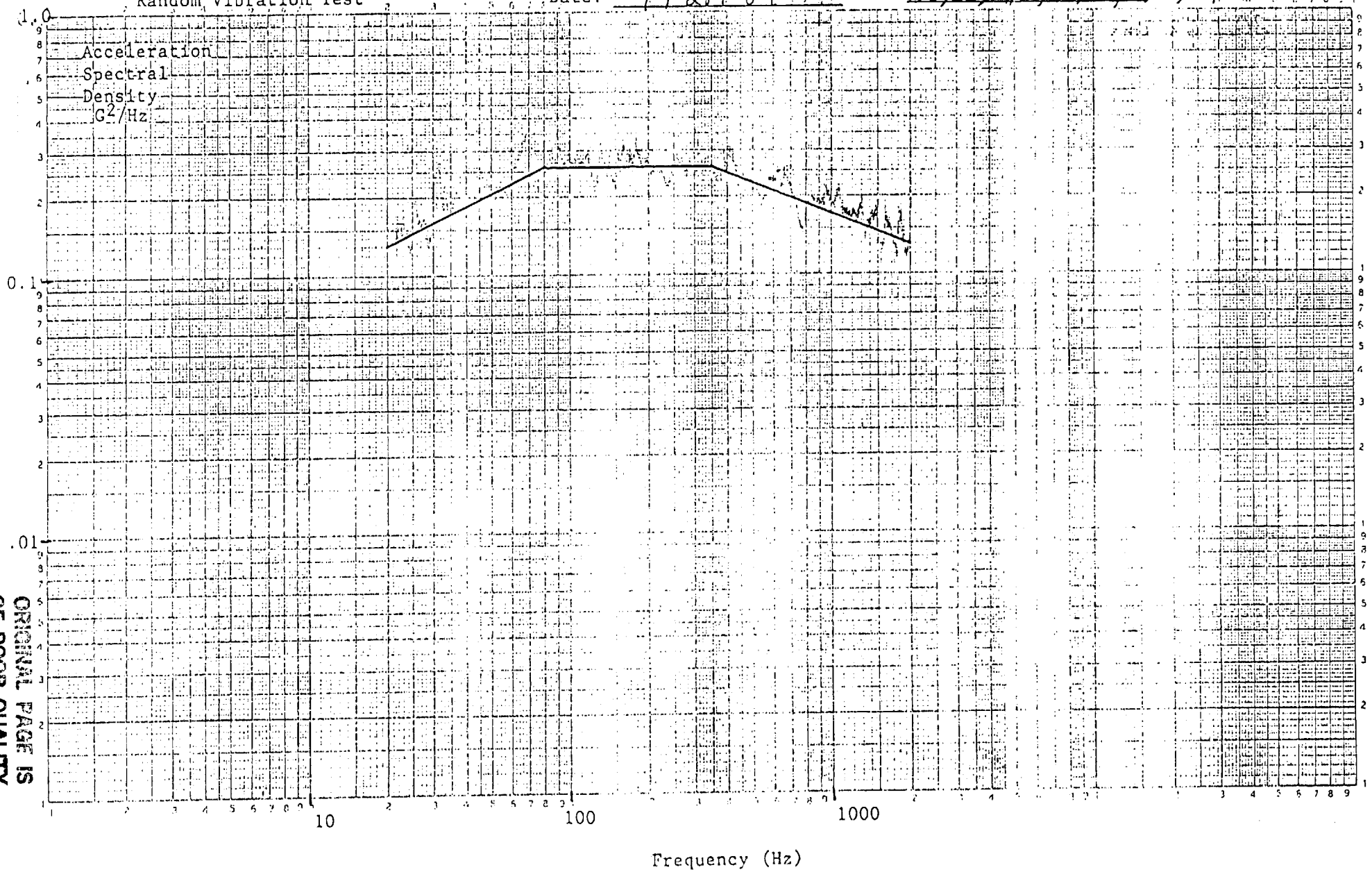


Wilson Greatbatch

Axis: Longitudinal Test Articles (10) Bcx149.00 Overall G's RMS=20.1

Random Vibration Test

Date: 9/28/89 S/N: 48, 35, 14, 21, 44, 26, 30, 18, 12, 34



Wilson Greatbatch

Axis: Vertical

Test Articles: (10 BCX149 00) Overall G's RMS=24.9

Randon Vibration Test

Date: 9/29/89

S/N: 48,35,14,21,44,26,30,18,12,34